Industrial QUALITY CONTROL

JULY, 1954 Vol. XI No. 1

TENTH ANNIVERSARY ISSUE

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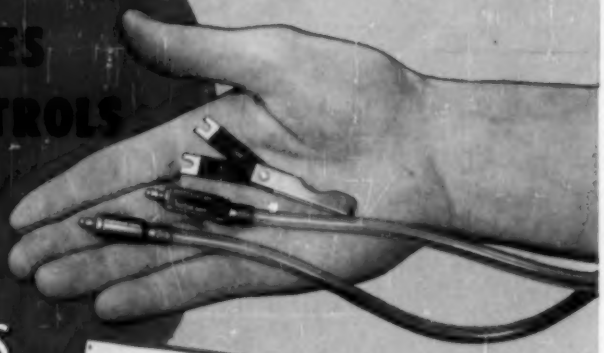

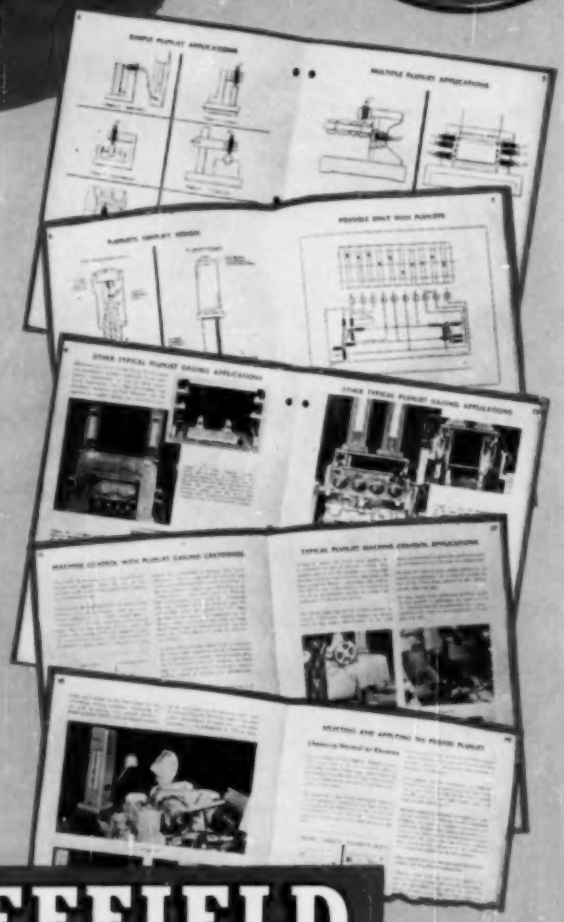

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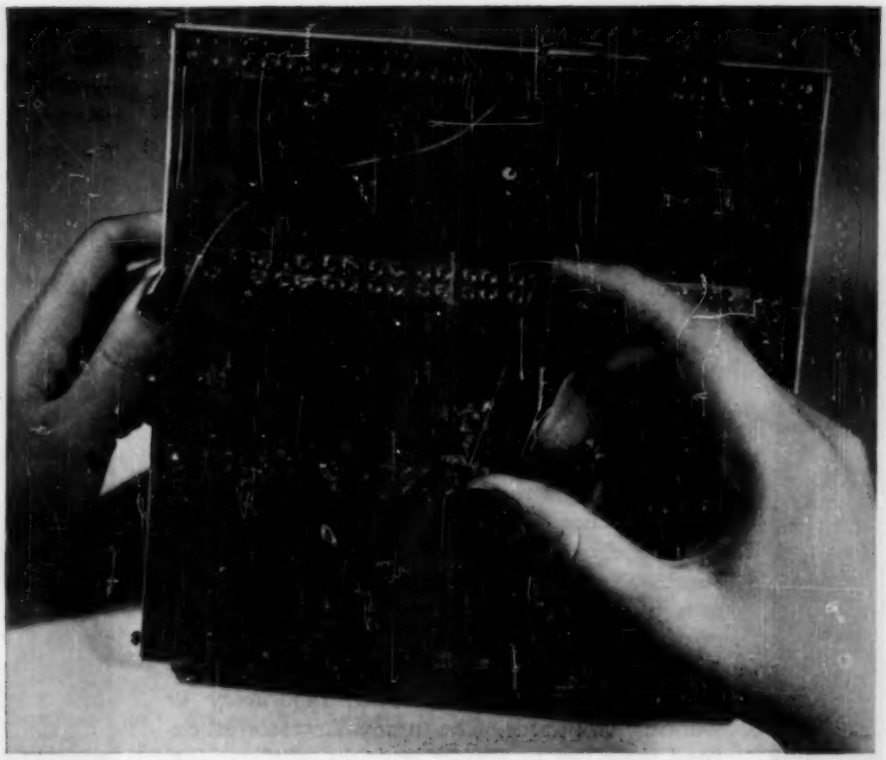

The Bell Solar Battery. A square yard of the small silicon wafers turns sunshine into 50 watts of electricity. The battery's 6% efficiency approaches that of gasoline and steam engines and will be increased. Theoretically the battery will never wear out. It is still in the early experimental stage.

Bell Solar Battery

Bell Laboratories scientists have created the Bell Solar Battery. It marks a big step forward in converting the sun's energy directly and efficiently into usable amounts of electricity. It is made of highly purified silicon, which comes from sand, one of the commonest materials on earth.

The battery grew out of the same long-range research at Bell Laboratories that created the transistor—a pea-sized amplifier originally made of the semiconductor germanium. Research into semiconductors pointed to silicon as a solar energy converter. Transistor-inspired techniques developed a silicon wafer with unique properties.

The silicon wafers can turn sunlight into electricity to operate low-power mobile telephones, and charge storage batteries in remote places for rural telephone service. These are but two of the many applications foreseen for telephony.

Thus, again fundamental research at Bell Telephone Laboratories paves the way for still better low-cost telephone service.

Inventors of the Bell Solar Battery, left to right, G. L. Pearson, D. M. Chapin and C. S. Fuller – checking silicon wafers on which a layer of boron less than 1/10,000 of an inch thick has been deposited. The boron forms a "p-n junction" in the silicon. Action of light on junction excites current flow.

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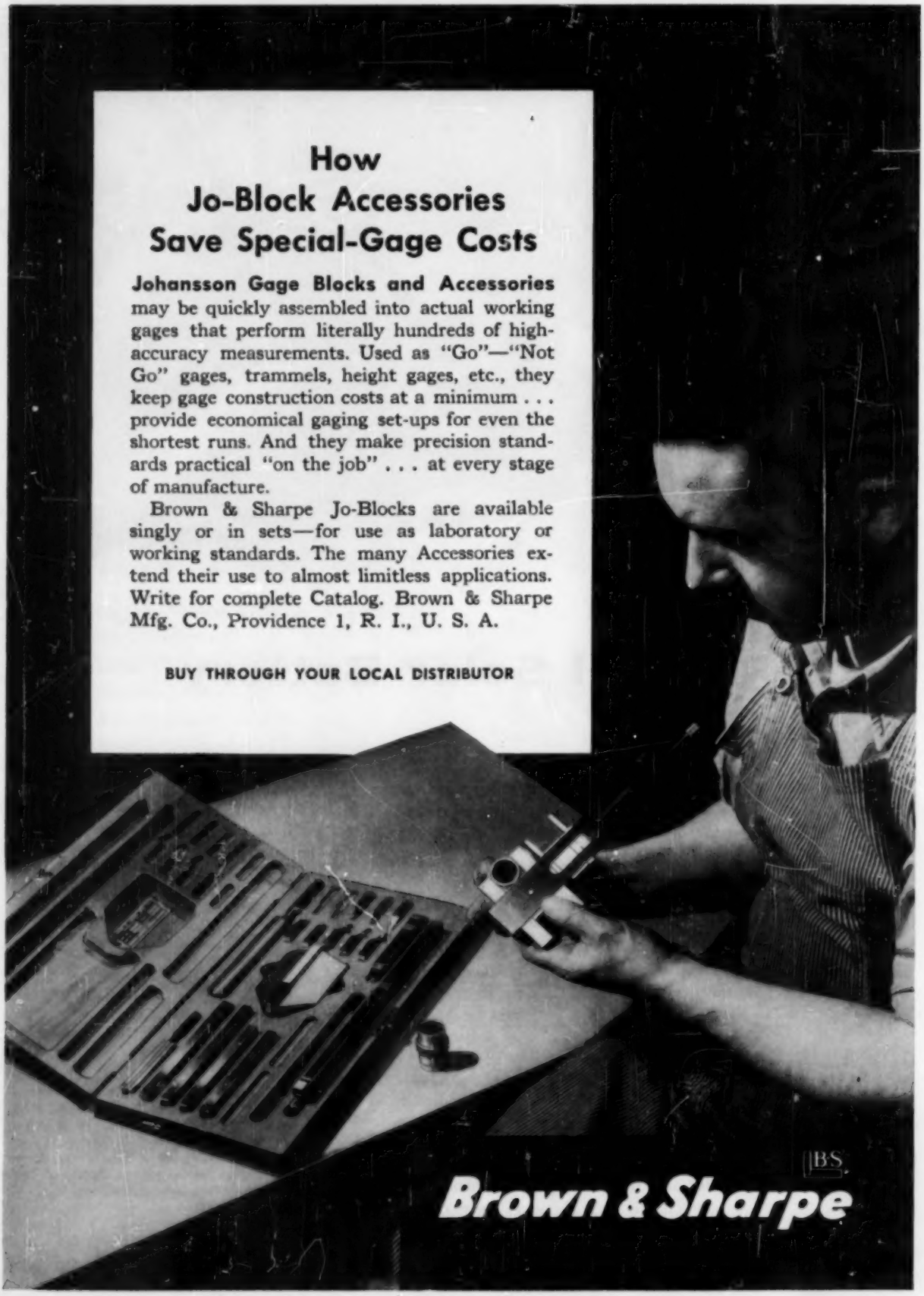
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Industrial Quality Control

Vol. XI JULY, 1954 No. 1

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AUTOMOTIVE TECHNICAL SUPPLEMENT

The Automotive Technical Committee is pleased to announce the publication of the Automotive Supplement No. 1. This booklet, similar to the Textile and Aircraft Supplements, is designed to provide a collection of technical papers which will be of interest to those members in the automotive field.

The Supplement may be obtained by members upon written request to American Society for Quality Control, 70 East 45th Street, New York 17, N. Y. All requests must be in New York prior to Sept. 30, 1954.

Copies of the Supplement will be available to non-members at $1.50 each. The charge of $1.50 will also be made to members requesting more than one copy and to those whose requests are received after Sept. 30.

American Society News

On Tuesday, June 8, the operating and executive committees met at the Jefferson Hotel in St. Louis, Mo. The major actions taken at this meeting are reported here.

A steering committee to investigate the desirability of an Applied Methodology Technical committee was established. Appointed to this committee are: C. C. Craig, chairman; Irving W. Burr, Charles A. Bicking, Paul S. Olmstead, John V. Sturtevant, and Arthur Bender, Jr.

The Business Operations steering committee was discharged as having completed its job. On the recommendation of the steering committee a permanent Administrative Applications Technical committee was established.

Four new sections completed all of the requirements for admission and were accordingly approved. The four sections which we welcome are:

77—Portland (Ore.)
Chairman: Richard C. Gearhart, Osborne Electric Co.
Vice-Chairman: Joel F. Kahn, Screw Machine Products Co.
Sec't'y-Treas.: William L. Miller, USAF

78—Danville-Sunbury (Pa.)
Chairman: Thomas G. Gregory, Thompson Products Co., Danville
Vice-Chairman: Harold Z. Snyder, Westinghouse Electric Corp., Sunbury
Sec't'y-Treas.: Charles A. Klase, Thompson Products Co., Danville

79—San Bernardino
Chairman: James A. Curry, Kaiser Steel Corp., Fontana
Vice-Chairman: Franklin B. Rossi, Norton AFB, San Bernardino
Secretary: James A. Butcher
Treasurer: Eldon E. Jory, Norton AFB, San Bernardino

(Continued on page 61)

We Celebrate the Tenth Anniversary of IQC

With this issue IQC begins its second decade. As can be seen from the current cover picture, Vol. I, No. 1 of our journal came into being in July 1944. It is appropriate to celebrate the tenth anniversary of this occasion by giving a run-down of the high lights in the first decade of life for IQC.

Industrial Quality Control antedates the American Society for Quality Control by 18 months. In November 1943 the graduates of an 8-day War Production Board training course in SQC, given earlier in Buffalo, N. Y., formed "The Society of Quality Control Engineers in cooperation with The University of Buffalo." One of the objectives of this group was the publication of a journal "to collect, analyze, and disseminate information concerning quality control as applied to industry." Implementing these decisions, this Buffalo group, under the editorship of Martin A. Brumbaugh (then Professor of Statistics, University of Buffalo) began preparations for publication which culminated in the first issue of IQC in July 1944.

It was a modest, 16-page, two-column per page, lithographed, bi-monthly publication, the first two issues of which were produced by William J. Keller Inc., Buffalo. The magazine filled a real need in the area of analytical quality control in industrial use and "caught on" rapidly, expanding to 20 pages with the November 1944 (No. 3) issue. This one and subsequent lithoprinted issues were produced at Colonial Radio Corp., Buffalo. By September 1945, IQC, although going back to 16 pages, was able to offer a three-column per page, letterpress format on a heavier stock paper, printed by Foster and Stewart, Buffalo. It was out of the cradle and beginning to walk!

In January 1946 a 20-page "Special Management Issue," Vol. II, No. 4A, was published in addition to the regular January issue, also increased from 16 to 20 pages. The purpose of this special issue was to bring to the attention of management concrete evidence of the existing state of quality control in industry and to document the scope and variety of profitable applications of SQC techniques.

The first paid ad in IQC appeared in the September 1945 issue—an ad inserted by the Columbia University Press announcing the availability of the "now unrestricted" Sequential Analysis of Statistical Data: Applications." The back cover page of the November 1945 (Vol. II, No. 3) issue saw the advent of the first full page ad, inserted by the Federal Products Corporation and never vacated by them in any issue since.

Meanwhile, other forces were afoot throughout the country which [to make a long story short] came to a climax in February 1946 with the founding of the American Society for Quality Control as a national organization uniting into one group seventeen local SQC quality control "societies." Among these was the Buffalo Society. Its publication, *Industrial Quality Control*, became the official journal of the newly formed national society, being transferred to it with a balance sheet which as of February 13, 1946 showed a net worth of $19.10! A 12-man editorial board (later to be increased) with Martin Brumbaugh as editorial chairman was appointed to guide the destinies of this new national publication.

The March 1946, Vol. II, No. 5 issue was the first appearance of IQC as the journal of ASQC. It contained 20 pages, five of which were devoted to matters of importance in connection with the newly formed national Society. It also embodied a slightly revised cover format which was to remain as the standard cover design for many subsequent issues.

Also in March 1946 the then five Midwest Sections of ASQC staged the First Midwest Quality Control Conference in Chicago, a two-day program that drew an attendance of some 1700 persons. No provisions had been made for publication of the proceedings of this conference, but the demand for some printed record was so insistent that IQC was expanded to 32 pages with the May 1946 issue to accommodate serially 19 of the 27 papers given on this program. Of the other 8 papers, either no manuscript was available or the paper substantially as presented at the conference was available elsewhere in the literature. The November 1946 issue completed the serial presentation of the Midwest Conference papers, but IQC continued to run at 32 pages.

In the spring of 1947 Martin Brumbaugh left the University of Buffalo to accept the post he has since held with Bristol Laboratories, Syracuse. Although he still continued to serve on the editorial board, he asked to be relieved of its chairmanship. On July 1, 1947 Mason E. Wescott, then a professor at Northwestern University, officially succeeded Brumbaugh as editorial chairman. Transferring to Rutgers University in 1952, Professor Wescott has served as editorial chairman since his appointment in 1947 except for a five-month leave of absence for a trip to India. During his absence (September 1952-February 1953), Professor Irving W. Burr of Purdue University served the Society as its acting editorial chairman.

Following the completion of Vol. IV in 1948, there was compiled and published an Index covering Vols. I-IV. Every volume since has been followed by the annual publication of an Index covering the volume just completed.

With the advent of Vol. V it became apparent that needed expansion in IQC was being handicapped by lack of adequate advertising. Several attempts to improve this situation had proved to be largely unproductive. In February 1949 Raymond S. Saddoris, now President of ASQC, agreed to serve as chairman of an Advertising Committee charged with the assignment of working out an effective advertising program for the journal. The success with which this assignment was carried out can readily be seen by a comparison of any issue of Vol. X with its counterpart in Vol. V

Vol. VI began in July 1949 with no indication of the several milestones that were to be passed by IQC during its six issues. The November issue, No. 3 of this volume, increased to 36 pages with 4½ pages of advertising. The January issue, No. 4 continued at 36 pages and carried a new cover design in two colors. The March issue, No. 5, dropped back to 32 pages but wore for the first time the basic two-color cover design which has since become the recognized signet of IQC. This was the first issue to be published for the Society by the Wisconsin Cuneo Press in Milwaukee, previous volumes and issues having been printed in Buffalo. Internal type fonts were also changed in both the January and March issues, but those appearing in the March issue have been the standard ever since. IQC now had a new home, a new face, and new raiment for the future.

But the real climax came with the advent of Vol. VI, No. 6—the big 116 page Convention Issue that appeared in May 1950. In addition to publicizing the Fourth Annual Convention of ASQC and the Fifth Midwest Conference to be held jointly in Milwaukee on June 1-2, 1950, this issue carried 13 articles and 56 pages of advertising. It gave the Society for the first time the feel of what its journal could ultimately become, and it served notice that IQC henceforth intended to move into big league circles.

At the Milwaukee meetings (June 1950) the editorial board was increased from 13 men plus the chairman to 15 men plus the chairman, and a five-year rotation plan for membership on this board was adopted. Under these provisions three new board members would take office each year to replace members whose terms had expired. Men on the editorial board roster as of May 1950 have been gradually retired in accordance with these provisions so that by July

1, 1955 the automatic five-year rotation plan will be in full effect.

During Vol. VII two issues were published at 48 pages, three at 40 pages, and a second Convention Issue of 116 pages in May carried 56½ pages of advertising and 9 articles. Advertising in the other five issues of this volume averaged 7⅛ pages per issue.

Vol. VIII came out with the first three issues at 48 pages, the next two at 52 pages, and another Convention Issue in May; this one at 150 pages with 9 articles and 75½ pages of advertising. Ads averaged 14.7 pages per issue in the other five issues of this volume. Also in Vol. VIII the No. 4 (January) issue was wrapped with a heavier stock cover which has been the standard cover stock since.

During Vol. VIII it became clear to the officers of ASQC that its journal and other publication needs of the Society required the establishment of a Publications Office under the direction of a full-time, salaried managing editor. Accordingly, such action was taken at the Sixth Annual Convention in Syracuse, N. Y., and a Publications Office was opened in Milwaukee in September 1952 with George R. Foster as managing editor.

This was a big step forward. It put the business and physical management of the journal and other publication activities of the Society on a sound, central, permanent, operating and operable basis. IQC was now "big business," equipped to fulfill the promise of its maturing stature as a big league publication.

Vol. IX maintained a steady 52 page size, a special, king-size Convention Issue, and a healthy growth in advertising income. During this volume, publication and editorship of IQC's companion magazine, the News Supplement, was gradually transferred from the supervision of E. H. Robinson of Johnson & Johnson in Chicago to the Publications Office in Milwaukee. Highlights in the history of the News Supplement may be found on page 3 of the September 1953 issue of IQC.

During Vol. X four accomplishments deserve attention. First, issues 2-3-4-5 ran at 64 pages, a significant further expansion in size of regular issue. Secondly, beginning with the November, No. 3, issue, the News Supplement was augmented by being made a regular department of IQC under the caption "Local Section News," thus providing a monthly exposure for this important facet of Society publication. Third, the Index to Vol. X was made a bound part of issue No. 6 (May) rather than mailing it out later as a separate insert with the first issue of Vol. XI as had been the practice for previous volumes. Finally, a questionnaire survey was made on a sampling basis to get a reflection of reader sentiment on several questions affecting editorial policy. One of these questions asked for a preference regarding the continuation of IQC as a bi-monthly journal or its expansion to a monthly basis.. Returns gave a clear indication that our Society is ready for a monthly journal as soon as such a move can be made safely from a cost standpoint. This is unquestionably the next big step forward for IQC.

Thus, on its tenth birthday, IQC can review with pride a record of healthy growth. It stands on the threshold of even wider usefulness to the Society, ready, as it were, to shift from knee pants to long trousers.

Only the high points of its physical growth have been set forth above. But there has been an exciting inner growth as well, probably too intangible to be documented adequately. However, it is possible to trace the origin of the various departments serving IQC readers.

American Society News (essentially the "president's page") has appeared in every issue since IQC became the official journal of ASQC in March 1946, Vol. II, No. 4.

Practical Aids made its first appearance in the July 1949, Vol. VI, No. 1 issue under the editorship of Professor Ellis R. Ott of Rutgers University and has been kept active under his supervision in many issues since then.

Book Reviews. Although book reviews were published in several earlier issues, it was the September 1949, Vol. VI, No. 2, issue that first saw this activity formally set up as a department under the editorship of Professor A. C. Cohen of the University of Georgia. He has since continued to manage this important activity for IQC.

Bibliography Department. Fairly complete bibliographies of early published quality control information can be found in Vol. I of IQC, but no systematic follow-up of the early project occurred until the St. Louis Section offered to our journal the services of an Editorial Committee with Joseph Movshin as Editor to screen available literature and report on titles of potential interest to IQC readers. The January 1950, Vol. VI, No. 4, issue saw the first appearance of this department. It has appeared without interruption under the guidance of Joe Movshin and the St. Louis Section in every subsequent issue of IQC.

Problems Department. This department first appeared in the March 1950, Vol. VI, No. 5 issue under G. Rupert Gause, Bell Telephone Laboratories, as editor. Following his request to be relieved of this assignment, editorship of this department was accepted by Professor Paul C. Clifford of Montclair State Teachers College who took over with the September 1951, Vol. VIII, No. 2 issue and has since managed this activity for IQC.

Management's Corner. Dr. J. M. Juran serves our journal as editor of this department which first appeared in the September 1951, Vol. VIII, No. 2 issue of IQC.

From the Scrap Box. First appearing in the January 1952, Vol. VIII, No. 4, issue, this department was intended initially as an IQC version of a "vox pop" or "letters to the editor" section. It has served in this capacity on several occasions as well as providing a medium for miscellaneous items of interest not readily classifiable elsewhere in IQC. It is under the joint supervision of the editorial chairman and the managing editor.

Local Section News, November 1953, Vol. X, No. 3, George R. Foster, editor.

What's New? The March 1954, Vol. X, No. 5, issue saw the advent of this department under Roy A. Wylie of Microswitch as editor. Its function is to keep IQC readers informed of latest developments in instrumentation and other allied equipment of potential interest to SQC operations.

These departments render special and continuing services to IQC readers which add significantly to its flavor and versatility. Nevertheless, general technical papers approved for publication through the editorial board are the backbone of our journal. Over the first ten volumes of IQC the character and calibre of these papers has followed a steadily discernible pattern of maturing growth. IQC is coming of age technically as well as physically along with the Society it serves.

When ASQC was formed the founders believed that the journal would become the core of the Society's service and the chief medium of communication between members (author-reader) and between members and management (notices and reports). From the editorial viewpoint we hope that these objectives are being attained with progressive efficiency. On this tenth anniversary congratulations go to IQC as the visible symbol of the maturity of ASQC. As editors, present and past, we are greatly pleased to express our thanks to the readers who have supported the journal; to the authors who have made the contributions and have been patient; to the editorial board who are loyal, able, and untiring; to the managements that have provided financial support in helping us get started. We believe that the first ten years were hardest; that we can now look forward to accelerated progress in subsequent decades.

Martin A. Brumbaugh

Mason E. Wescott

An Optimum Procedure for Setting Machines or Adjusting Processes

FRANK E. GRUBBS

Ballistic Research Laboratories, Aberdeen Proving Ground, Md.

INTRODUCTION

An important problem in industry is that of adjusting or setting machines. An important aspect of this problem has been dealt with by Burr,[1,2,3] who made a detailed and valuable study concerning whether or not a machine or process could be *approved* for level of operation on the basis of measurements made on piece parts or items from the process. Using a sequential sampling approach, Burr's procedure is to test the hypothesis of whether there should be a change in some "trial" setting which has already been made. In this article we consider a somewhat different problem: namely, that of determining just how one should go about adjusting the machine or process to the desired level. It can be said, however, that the present treatment may also represent another approach to the overall problem of process adjustment.

THE ADJUSTING PROBLEM

It is a well-known fact that for a given or constant setting, a machine or process will turn out items or piece parts which exhibit variation. The measurements and actual sizes of the piece parts or items will generally be clustered about some mean or central value. The variation from item to item, which can be described rather efficiently by means of the standard deviation, is a measure of the precision of the machine or process, or alternatively may be called the product variability. Of course, the size of the product variability (and the errors in measurement) will have some influence over any recommended adjustment procedure. In this connection, however, we will make the logical and allowable practical assumption that the process is capable of being adjusted in level. In other words, the product variability and precision of measurement should for the most part be acceptable with respect to the specification limits. We also assume here that the effect of a unit change in setting on the relative change in average size of an item made by the process is known or can be estimated fairly accurately.

We define the problem of setting a machine or process as that of adjusting the true or mean value of the items produced to the desired level. We do not intend to accomplish any more than this in many cases because there will be random variations from item to item and generally speaking it will only be economical to center the mean level of the items close to the desired value, without trying also to reduce dispersion. In the actual application of an adjustment technique, an operator would start the machine, make one or more items, measure the items and decide whether the machine setting should be changed. On statistical grounds, we know that the operator must then exercise care in adjusting the machine or process on the basis of measurements made on a few items as he may be misled because of the inherent variation, or standard deviation from item to item and errors of measurement.

Now suppose at first we simplify the procedure by saying that we make a single item and measure it (even with random error), that we compare this measurement with the desired level, and then make a change in the machine setting. We then produce another item, measure it and adjust the machine again, etc. Our problem, then, is just what shall we do with the deviations, or the differences between the measured values of the items and the desired level, in adjusting the machine, or just what corrections to the machine setting should be made after measuring each item.

RECOMMENDED ADJUSTING PROCEDURE

Our recommendations are simply the following: After producing the first item, we adjust the machine or make a correction in setting which amounts to the difference between the desired level and the measured value of the first item. When the measured value of the first item is greater than the desired level, then the machine or process is, of course, adjusted so as to decrease the size of the next item, and vice versa. After making this adjustment and producing the second item, we make a correction in level of the machine equivalent to only *one-half* the difference between the desired level and the measurement of the second item. The adjustment after the third item is to be only *one-third* the deviation of the measured value of the third item from the desired level. Thus, in general after producing the nth item the correction or adjustment to be made should be only 1/n of the measured deviation of that item from the desired level. By following this procedure it is guaranteed that the true mean level of the items produced will converge rather rapidly to the desired level.

This procedure can also be extended to groups of items. For example, suppose we desire to produce items in groups of five or to sample for groups of five items each from the production process between adjustments. Then we would make a full correction for the deviation of the average of the first group, only one-half for the deviation of the second group average from the desired level, one-third the deviation of the third group average from the desired level, etc. Of course, if it happens that the machine is properly set to begin with and the product variability or the errors of measurement are relatively large, then one would mistakenly adjust the machine initially; however, it is believed that this would be an unusual case which need not concern us much in practice, especially since the above recommended procedure would still readjust the machine to the desired or proper level anyway.

It should be noted that our procedure for adjustment is recommended even though errors of measurement are made on the items, although the larger the errors of measurement the longer the time that may be required to adjust the process average to the desired level. A proof of this statement and the justification for making the corrections indicated above are given in the Appendix.

We point out that one would expect the sizes of the adjustments to approach a very small value or zero because of the factor $1/n$. Therefore, as a practical rule it may be proper and convenient to stop adjusting the machine when changes in setting are no longer indicated for several consecutive items or when $\sigma/\sqrt{n}$ discussed in the next paragraph is suitably small.

The precision or standard deviation of the final adjusted level is a minimum value and is given by $\sigma/\sqrt{n}$, where the standard deviation of *measured* items $\sigma = \sqrt{\sigma^2_x + \sigma^2_e}$, σ_x is the true standard deviation from item to item or product variability, σ_e is the standard error of measurement,* and n represents the number of adjustments made or the number of items considered in the adjustment procedure. (If adjustments are made using averages after each group for k groups of n items each, then the standard deviation of the final adjusted level would, of course, be $\sigma/\sqrt{kn}$.) Hence, the standard deviation of the final adjusted level is equal to the standard deviation of an ordinary sample average (for no change in level) and this can be made arbitrarily small by a suitable choice of the number of items which are to be measured and used in the adjustment process. Moreover, we would expect that the adjusted level after n items or corrections would almost always be within, say, $\pm 2\sigma/\sqrt{n}$ of the desired level.

For the curious reader, two different models or concepts of adjusting processes are discussed in the Appendix.

Example: The specifications for a certain dimension of a metal part are 0.210 ± 0.008 in. and it is desired to set the machine so that the process average will coincide with the level 0.207 in. (In this case, it was necessary to conduct a preliminary study—a regression analysis—to estimate the relative dimensions of piece parts turned out by the machine as a function of the position of the setting device; i.e. the setting was "calibrated" relatively). The first metal part made was measured and found to be 0.201 in. Following the recommendations herein, the machine was thus adjusted so that we would expect the next part to be (0.207 − 0.201) = 0.006 in. larger for the dimension under consideration. The second metal part was made after the above adjustment and measured 0.213 in. The machine was therefore adjusted "downward" by only ½ (0.213 − 0.207) = 0.003 in. The third part measured 0.210 in. and the machine was adjusted "downward" by only ½ (0.210 − 0.207) or 0.001 in. The measurements of the 4th, 5th, 6th and 7th metal parts indicated that the required adjustments were so small that they could not be made on the machine; therefore, the process of adjustment ended and the machine allowed to run until resetting became necessary.

*See reference 4 for techniques of estimating product variability and precision of measurement. In many applications σ_e could, for all practical purposes, be considered zero as compared to σ_x.

CONCLUSIONS

If, for a constant machine setting, one were to select n items and make a correction in level based on the average of these items, it is true of course that the adjusted level will also have a standard error of $\sigma/\sqrt{n}$. Thus, although the practical utility of our recommendations has not been very fully explored, it would appear that the value of the proposed procedure would be that (1) it results in an optimum technique for handling a *series* of corrections in the adjustment process for either setting or resetting a machine, (2) convergence or an orderly approach to the desired level is guaranteed, thereby precluding "over-setting," "under-setting," "wandering," unnecessary waste of product, etc. and (3) the operator, by noticing successive settings, would have some assurance that the machine is capable and that the desired setting is being approached properly.

In some applications, quantitative measurements are not available and one has to rely on go no-go or qualitative measurements. Thus, the setting may be "high" or "low", "over" or "short" of the mark, etc. In this connection, we remark that in artillery firing one adjustment procedure is to change the range for each shot by four probable errors until the target is bracketed with an "over" and a "short". Then n rounds are fired at the center of the bracket and the center of impact moved into coincidence with the target according to the formula

$$\frac{2(n_s - n_o)}{n}\,PE \qquad PE = .6745\sigma$$

when n_s, n_o and n are the number of "shorts", "overs" and rounds fired respectively. The *adjusted* range is taken as the mid-point of the bracket plus the above fraction[5]. This procedure may be of some use in adjusting machines or alternatively one may well consider a stochastic process of the type

$$L_{n+1} = L_n \pm \frac{1}{n}(k\sigma)$$

where L_n is the level for the nth item, L_{n+1} the level for the (n+1)st item and k is taken as perhaps 2 or 3 initially, depending on the particular application (σ is the product variability). The plus sign is used if the nth item is too small or "short" and the minus sign if it is too large or "over".

Finally, we remark that the procedure for adjustment recommended herein is not restricted to setting a machine, but also may be used for calibrating instruments, firing at targets, etc.

Appendix

It is assumed that we aim to place the population mean, μ, on the desired level or target value, T. Let the product variability or deviations from the population mean be represented by the random variables x_1, x_2, x_3, etc. The mean or expected value of the x_i is zero; i.e. $E(x_i) = 0$, and the variance of x_i is given by $E\{x_i - E(x_i)\}^2 = \sigma^2_x$, say. Let d represent the true deviation of μ from the target value T before the first item or piece part is made. Of course, d is unknown and cannot be determined directly. Let e_1, e_2, e_3, etc. be the errors in measuring the deviations of the values of the items from T. We assume that the errors of

measurement, e_i, have a mean value, $E(e_i) = 0$ and variance σ^2_e. Moreover, e_i and x_i are considered to be statistically independent.

Now the true value for the first item produced is $T+d+x_1$ or the first population mean is located at

$$\mu_1 = T+d \tag{1}$$

Note that we know T, the desired level and can measure $d+x_1$ directly, but as already indicated d is not directly measureable, for if it were there would be no problem!

After producing the first item, we try to determine the deviation, $d+x_1$, or difference in measured value of the first item and the desired level, but we can only estimate this difference, thereby making an error e_1 in so doing. We thus judge the deviation of the first item from T to be in actuality $d+x_1+e_1$ and our correction in setting will be, say, $k_1(d+x_1+e_1)$, before making the second item.

In producing the second item, its true value will therefore be $T+d-k_1(d+x_1+e_1)+x_2$, or the new (second) population mean will be at

$$\mu_2 = T+(1-k_1)d-k_1(x_1+e_1) \tag{2}$$

We estimate the deviation, $(1-k_1)d-k_1(x_1+e_1)+x_2$, of the second item from the desired level T, but make the error e_2 in doing this, so that we correct the machine setting by the quantity

$$k_2[\,(1-k_1)d-k_1(x_1+e_1) + x_2 + e_2]$$

Thus, the population mean, μ_3, for the third item is

$$\mu_2-k_2[\,(-k_1)d-k_1(x_1+e_1) + x_2 + e_2]$$

or

$$\mu_3 = T+(1-k_1)\,(1-k_2)d-k_1(1-k_2)\,(x_1+e_1) -k_2(x_2+e_2) \tag{3}$$

Continuing this process, by making the corrections k_3, k_4, etc. times the deviations of the measured values of the 3rd, 4th, etc., items from T, we find that in general the population mean for the (n+1)st item will be located at

$$\mu_{n+1} = T + \prod_{i=1}^{n}(1-k_i)d - \sum_{i=1}^{n} k_i \prod_{r=i+1}^{n}(1-k_r)\,(x_i+e_i) \tag{4}$$

where we must specify that

$$\prod_{r=n+1}^{n}(1-k_r) = 1$$

Our problem is to determine the quantities, k_i, or the fractional corrections which should be made in the adjustment process. We will determine the k_i so that the final population mean, μ_{n+1}, will have minimum variance and also we want to satisfy the condition that the mean or expected value of μ_{n+1} will be equal to T.

From Eq. (4) we have

$$E(\mu_{n+1}) = T + \prod_{i=1}^{n}(1-k_i)d \tag{5}$$

so that our adjustment procedure will be unbiased only if

$$\prod_{i=1}^{n}(1-k_i) = 0 \tag{6}$$

Hence, Eq. (6) is a side condition or additional restriction which must be satisfied.

Now the variance of μ_{n+1} is $E\left[\mu_{n+1}-E(\mu_{n+1})\right]^2$ and is given by

$$\text{Var}\,(\mu_{n+1}) = \sum_{i=1}^{n} k^2_i \prod_{r=i+1}^{n}(1-k_r)^2\,(\sigma^2_x+\sigma^2_e) \tag{7}$$

To find the optimum k_i, we utilize the Lagrange multiplier, λ, and minimize Eq. (7) subject to the side condition of Eq. (6); i.e. we set

$$f(k_i) = \sum_{i=1}^{n} k^2_i \prod_{r=i+1}^{n}(1-k_r)^2\,(\sigma^2_x+\sigma^2_e) + \lambda \prod_{i=1}^{n}(1-k_i) \tag{8}$$

and equate $\dfrac{\partial}{\partial k_i} f(k_i)$ to zero. Since

$$\prod_{i=1}^{n}(1-k_i) = 1-\sum_{i=1}^{n} k_i \prod_{r=i+1}^{n}(1-k_r)$$

we find that

$$2k_i \prod_{r=i+1}^{n}(1-k_r)^2\,(\sigma^2_x+\sigma^2_e) - \lambda \prod_{r=i+1}^{n}(1-k_r) = 0$$

That is

$$k_i = \frac{\lambda}{2(\sigma^2_x+\sigma^2_e)\prod_{r=i+1}^{n}(1-k_r)} \tag{9}$$

But since

$$\sum_{i=1}^{n} k_i \prod_{r=i+1}^{n}(1-k_r) = 1$$

due to the side condition, then

$$\lambda = \frac{2(\sigma^2_x+\sigma^2_e)}{n} \tag{10}$$

and thus

$$k_i = \frac{1}{n\prod_{r=i+1}^{n}(1-k_r)} \tag{11}$$

Therefore,

$$k_n = \frac{1}{n},\ k_{n-1} = \frac{1}{n-1},\ \ldots\ k_2 = \tfrac{1}{2} \text{ and } k_1 = 1 \tag{12}$$

Upon substituting the k_i into Eq. (7), we find that

$$\text{Var}\,(\mu_{n+1}) = \frac{\sigma^2_x+\sigma^2_e}{n} \tag{13}$$

The reasons for our statements in the text are therefore clear.

The reader's attention is directed to the fact that there exists a somewhat different concept compared to that just indicated or an allied model. Suppose, for example, that due to day-to-day changes, shift-to-shift changes, unknown shifts in level of a machine for a given setting due to repair work, etc. (or for a large battery of machines), one might consider that on the jth occasion (or for the jth machine) the change or shift in the population mean before producing the first piece part or item is d_j and that d_j over many occasions (or machines) is a random variable with zero mean and variance σ^2_d. The concept here is that on the average, over many occasions (or for many machines) we desire accuracy of adjustment without paying too much attention to individual occasions (or machines). For such a model, then Eq. (4) becomes

$$\mu_{n+1} = T + \prod_{i=1}^{n}(1-k_i)\,d_i - \sum_{i=1}^{n} k_i \prod_{r=i+1}^{n}(1-k_r)\,(x_i+e_i) \tag{14}$$

The expected value of μ_{n+1} is now

$$E(\mu_{n+1}) = T \tag{15}$$

so that the restriction

$$\prod_{i=1}^{n} (1-k_i) = 0$$

is no longer required. Moreover, the variance of μ_{n+1} is given by

$$\text{Var}(\mu_{n+1}) = \prod_{i=1}^{n} (1-k_i)^2 \sigma^2_d + \sum_{i=1}^{n} k^2_i \prod_{r=i+1}^{n} (1-k_r)^2(\sigma^2_x+\sigma^2_e) \tag{16}$$

Equating the derivative (with respect to k_i) of Eq. (16) to zero, we find after considerable reduction that

$$k_i = \frac{1}{i + \dfrac{\sigma^2_x+\sigma^2_e}{\sigma^2_d}} \tag{17}$$

instead of $k_i = 1/i$ as before, and

$$\text{Var}(\mu_{n+1}) = \frac{\sigma^2_d(\sigma^2_x+\sigma^2_e)}{n\sigma^2_d+\sigma^2_x+\sigma^2_e} \tag{18}$$

Calling this latter concept Case II and the previous model for constant d, Case I, we note that

$$\frac{\text{Var}(\mu_{n+1})\ \text{Case I}}{\text{Var}(\mu_{n+1})\ \text{Case II}} = 1 + \frac{\sigma^2_x+\sigma^2_e}{n\sigma^2_d} \tag{19}$$

Thus, the precision for the adjusted population mean for Case II is somewhat better than that for Case I. However, it is easily seen that for a given occasion (or machine) for the model of Case II that the adjusted level, μ_{n+1}, may not be as *accurate* at that for Case I because of the extra term,

$$\prod_{i=1}^{n} (-k_i)d_i$$

in Eq. (14). Application of the Case II assumption would require some knowledge of the product variability, σ_x, the precision of measurement, σ_e, and the variability for the initial machine levels, σ_d, for each type machine, process, etc. (or for the machines of a battery).

To sum up, therefore, the corrections or adjustments for Case I; i.e. $k_n=1/n$, are very simple and easily remembered, they require no special investigations to determine σ_x, σ_e and σ_d for each process, etc., they result in accuracy on every occasion or for each machine and an practical grounds may be nearly as precise as those for Case II. In fact, it is probably true that the required precision can be accounted for easily by proper choice of n, thus making the difference indicated by Eq. (19) somewhat academic. Therefore, as a rule of thumb, we would recommend the concept of Case I and the simple corrections $k_n=1/n$.

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A Method for Defect Evaluation

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The use of statistical sampling plans for inspection by attributes has found increasing acceptance in industrial practice as a method for controlling the quality of finished products. Each of the sampling procedures commonly employed in these inspection processes; i.e., single, double, multiple and sequential sampling plans, is based upon the frequency of occurrence of defects in a random sample from a submitted lot. On the basis of the sample evidence, action decisions are made on the lot.

In many products, however, there are various classifications of defects of which some are considered of major importance and others are relegated to a minor status. Therefore, the required total which forces rejection of the entire lot becomes dependent upon the definition of a rejectable defect and the equivalence rating which is assigned to these characteristics which are classified as undesirable, although of lesser importance.

The general definition of a defect in the latter case is an undesirable attribute which detracts from the salability of the product. The extent to which this detraction occurs for each of the defects under consideration cannot be quantitatively measured and is therefore determined by individual opinion on the basis of experience and industrial practice. Unfortunately, there are as many opinions concerning the relative demerits of specific defects as there are people expressing them. It is entirely possible, under these conditions, that the same lot of finished material can be either accepted or rejected depending upon the standards which are used and the individual opinions upon which these standards are founded.

There is an urgent need for a method which will enable a quantitative evaluation of varying degrees of defects to be made. Then generally acceptable sampling procedures would be readily obtainable for the controlled inspection of materials and justifiable conclusions could be obtained concerning their acceptability. It is the purpose of this paper to present such a method and illustrate its application.

THE RANKING METHOD

The method discussed here is a modification of the quantitative ranking method first introduced by Churchman and Ackoff[1] in an effort to establish a basis for policy-making decisions. This procedure is predicated upon opinion in order to establish quantitative relationships among variables which cannot be otherwise obtained by theoretical considerations or by previous data resulting from past performance. These opinions are solicited either individually or collectively and indicate preferential merits of each variable as compared to the value of combinations of variables within the same system. The final decision is reached after continuous re-evaluations of each variable and a relative ranking established on an arbitarary scale which is consistent with each of the decisions reported during the evaluation process.

The first step in the procedure is the tentative listing of variables in the order of their importance. The variable at the head of the list is arbitrarily assigned a value of 100 and the remaining variables are assigned numerical values indicating their estimated importance relative to this variable. These values are qualitative in nature and serve only as a temporary ranking for subsequent readjustment.

The individual, or group, is then requested to register an opinion as to the relative merit of the initial variable as compared to the combined effect of the second and third variable in the listing. The three possible responses to this question are (1) the initial variable is more important than variables two and three, (2) it is less important, (3) they are equal. In the case of the first response, the value of 100 assigned to the initial factor must exceed the combined value assigned to the second and third variable which were used for this comparison. Conversely, the latter total must exceed 100 if the second response is received. Obviously, they must be equal in the event of the third response. This procedure is repeated until the initial variable has been compared with all combinations of two variables within the previous listing. Each decision is recorded and adjustments made to concur with existing and previous decisions.

In a similar manner, the second variable is compared with combinations of variables below it in the original listing. This process is continued until each variable has been evaluated and the numerical values adjusted to conform with the individual decisions.

Through continuous adjustment of the original numerical ratings, it is quite possible that the original ranking will be altered at the conclusion of the evaluation. A significant rearrangement may necessitate a revised listing and a second trial, although this should be obvious in the early stages of the procedure.

APPLICATION OF METHOD

The inspection of finished packages in the pharmaceutical industry represents a typical operation to which this method has been applied. Both the attribute type of defect and the variable type defect are prevalent in this inspection process and must be considered relative to their respective effects on product quality. It is recognized that these defects have varying importance as to their contribution to rejectability of the lot and must, therefore, be weighted accordingly. The selection of the defects are the result of the considered opinion of a responsible panel within the quality control group. In this particular case, each defect is considered an attribute and is either present or absent in the individual vials. The only limitation to the inclusion of each defect was in its definition, such that each defect could be solely responsible for lot rejection if that defect was present in a majority of the packages within a lot.

The previous standards for the acceptance or rejection of individual lots were based upon the classification of defects into two categories; namely, major and minor. An arbitrary scale was drawn in which ten minor defects, regardless of type, were equivalent to each major defect. This method of rating is commonly accepted in industrial practice. However, there was considerable disagreement among the responsible personnel concerning the above equivalence rating as well as the differentiation between the two kinds of defects. Therefore, it was deemed advisable to install an acceptance standard for this operation to which all members of the panel could subscribe and in which each defect could be ranked with its respective numerical rating.

In this experiment, the panel consisted of nine men with widely varying concepts as to the relative importance of the defects under consideration. The use of group opinion in the ranking method was accomplished by accepting majority rule on each comparison and regarding the collective decision as a single response.

The defects which were included in this evaluation were specifically defined to provide for equivalent comparisons among the nine members of the panel. Decisions were made by open ballot although discussion of the specific responses was prohibited. The periodic adjustments conforming to each decision were performed in full view of the participating panel.

EXPERIMENTAL RESULTS

The initial ranking of all the defects by individual members of the panel was requested along with their respective ratings. The defect at the head of the list was assigned a value of 100 and the remainder placed in a descending order with numerical values proportionate with the first defect. An average of all the values for each defect was calculated from the grouped opinions and these ratings became the starting point of adjustment. In the general case, we may designate these defects as A to F. The initial assessment is shown as:

Variable	(A)	100
"	(B)	60
"	(C)	55
"	(D)	44
"	(E)	34
"	(F)	27

A series of comparisons were offered to the panel in the manner described previously. With each decision the numerical values were adjusted, if necessary, until all possible combinations for comparative purposes were exhausted. A partial list of comparisons and decisions is shown in Table I.

It will be noted that the first and second decisions of the group did not necessitate any adjustment since the sum of the values representing the second and third variables was already in excess of the value for the leading variable. The third opinion poll, however, showed that the consensus was in favor of B and E over A although the original assessment was 94 vs. 100 in favor of the leading variable. A necessary adjustment was then made such that the numerical ratings coincided

with the majority decision. In this case, variable B was arbitrarily increased from 60 to 70. The experimenter should not be too much concerned as to the particular variable to be adjusted or the exact amount of adjustment as the adjustment itself may, in turn, be considered tentative and subject to re-evaluation by future comparisons.

The fourth decision shown in the table was evaluated by the numerical ratings using the adjusted value of B as 70 and, again, did not cause further change in the defect assessment tabulation. The next decision, the fifth, conformed with the existing ratings but began to indicate a decided trend toward the relative importance of the variables in question. The combined sum of C and D is shown in the initial rating as 99, or one unit less than the top value of 100. Yet the members of the panel voted strongly in favor of A over C and D as evidenced by the 7 to 2 majority. Therefore, future adjustment would tend to lower the values ascribed to these variables, C and D, in the event that further adjustment of the variables were necessary.

The method of adjustment was repeated as each individual decision was recorded. At each change, the resultant tabulation became the basis for further adjustment. Special mention may be made of decisions 10 and 20, as these indicate an equality between groups of variables and must be taken into consideration. In each case, the immediate adjustment conformed with all previous decisions as well as the current one.

The final ratings, based upon the above procedure, are shown as:

Variable	(A)	100
"	(B)	82
"	(C)	43
"	(D)	38
"	(E)	24
"	(F)	13

At this point, the experimenter must review all comparisons and check the majority decisions against the final ratings for conformance. Decisions 10 and 20, B vs. C and D and D vs. E and F, are shown as nearly equivalent as possible and still enable the other comparisons to be valid.

DISCUSSION

The use of statistical sampling plans can now be applied to this packaging operation by assuming the leading variable to be a major defect and evaluating the succeeding variables on the basis of the above ratings. Therefore, variable B is 0.82 of a major defect, variable C is 0.43 of a major defect, etc. As a matter of record, a majority decision was obtained concerning this assumption prior to its acceptance in the inspection procedure.

If we consider a single sampling plan described in the MIL-STD-105A Tables, it is found that for a lot size of 40,000 units and an Acceptable Quality Level of 0.65%, a maximum of 7 defects is allowed in a sample of 450 prior to its rejection. However, the critical score for rejection has been set at a maximum value of 8.000 in order to avoid a range of indecision between 7.000 and 8.000. Therefore, 8.000 becomes the maximum allowable score for the inspection process on the basis of the final ratings of the defect evaluation. During the inspection, the frequency of occurrence of each defect in the sample is recorded and the total frequency of a defect multiplied by the numerical value established for that defect. These cross-products are added to obtain the total score which must not exceed the value of 8.000 in order for the entire lot to be accepted. Conversely, if the total score had been greater than 8.000, the entire lot would be rejected and returned for reprocessing.

It is readily apparent that a review of the inspection chart may indicate the assignable cause for rejection and suggest the type of reprocessing necessary for acceptance. In this event, the further processing is carried out on the entire lot, 100 percent inspection, and a second random sample of 450 taken for inspection evaluation.

An example of such an occurrence can be illustrated by a faulty capping operation in the assembly of the finished package. In this illustration, the number of units within the sample containing skewed caps was sufficiently large so that its contributory score was cause for lot rejection. Then, the entire lot was placed on a conveyor belt and subjected to complete inspection for bad caps. The lot was then reassembled and randomly sampled for a second inspection. At that time, the sample was examined for all defects and a second total score obtained which enabled the lot to be passed.

Perhaps the most significant accomplishment of the ranking method was the establishment of a standard procedure for inspection where an arbitrary procedure had existed previously. By setting quantitative values for rejection and acceptance, the inspection procedure was taken from the realm of individual opinion and became independent of personal prejudice concerning the relative importance of each of the defects under consideration. Moreover, during the evaluation procedure, the decision-making group has occasion to examine each defect in a number of different comparisons and establish its own preferences with a greater degree of confidence.

Finally, it should be pointed out that each member of the panel expressed satisfaction with the final ranking and felt that the resultant values coincided with his own *a priori* opinion concerning the relative merits of the defects under discussion.

TABLE I—Comparisons of Defect Combinations

Decision No.	Comparison	Decision Yes	No	Equal	Majority Decision
1	A > (B+C)	2	7	0	No
2	A > (B+D)	2	6	1	No
3	A > (B+E)	3	5	1	No
4	A > (B+F)	6	1	2	Yes
5	A > (C+D)	7	2	0	Yes
6	A > (C+E)	9	0	0	Yes
7	A > (C+F)	9	0	0	Yes
8	A > (B+C+D)	1	8	0	No
9	A > (B+C+E)	1	8	0	No
10	B > (C+D)	4	2	3	Yes
11	B > (C+E)	6	1	2	Yes
12	B > (C+F)	8	0	1	Yes
13	B > (D+E)	9	0	0	Yes
14	B > (D+F)	9	0	0	Yes
15	B > (C+D+E)	2	5	2	No
16	C > (D+E)	2	7	0	No
17	C > (D+F)	1	8	0	No
18	C > (E+F)	5	2	2	Yes
19	C > (D+E+F)	0	7	2	No
20	D > (E+F)	1	4	4	Equal

CONCLUSION

The ranking method for defect evaluation enables a quantitative relationship between defects to be established for inspection purposes. The ratings are determined by a survey of opinion. A system of continual re-evaluation and adjustment is employed which conforms with each of the decisions reached by a panel whose collective opinions determine the policy of the inspection procedure. The utilization of these numerical ratings, combined with statistical sampling tables, then provides a single-valued criterion on which to base acceptance or rejection of inspected material.

References

1. C. W. Churchman and R. L. Ackoff, "An Approximate Measure of Value," presented before the Operations Research Society of America, May 16, 1952.
2. The referee who studied this paper directs the interested reader's attention to the work of Guttman and others on related problems (Annals of Mathematical Statistics, 17 (1946) 144 ff, and Volume 4 of the American Soldier by S. A. Stouffer, et.al.), pointing out that the methods reported in these references were used to develop the point system for demobilization after World War II.

Controlling the Control Laboratories

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"Let's send another sample to the laboratory. This batch can't be as bad as they say it is. Something must be wrong with their analysis."

You may never have heard a production foreman say this, but I and a good many others have. It does not give you a comfortable feeling, if you are associated with the laboratory involved. This desire to send another sample to the laboratory stems from two sources. One is lack of confidence in the laboratory's performance. The other is a little more subtle. I think it must be a feeling that if enough samples can be taken and enough undesired results discarded (righteously, because the laboratory is wrong), then eventually a correct (desirable) result can be obtained.

It is proposed in this article to discuss some of the steps which can be taken to help remedy any lack of confidence which might exist. The discussion applies to control laboratories generally, but the illustrations are taken from laboratories in a chemical fiber manufacturing plant because I am most familiar with these.

But first, let us review the purpose of a control laboratory. Stripped of all of its trimmings, its chief job is to sample a product, test or analyze it for a quality, and report the results in a form suitable for use by the production department as a basis for making decisions and taking action. Moreover, all of this must be done in a manner which makes the results have validity, the required precision, be in a state of statistical control as far as the laboratory's own work is concerned, and be available in time for use.

CONTROL OF ANALYSTS

Analysts need instruction in what they are to do. The kind of instruction they receive has considerable influence on the quality of the results reported by the laboratory. For example, if two analysts are told simply to weigh out five grams of a certain reagent to be used in a routine analysis, one analyst may very well decide to use a four-place analytical balance and the other to use a trip balance. In such a case the precision of the test method would likely be different for the two men. Likewise, the precision or even accuracy of a test could be affected by leaving a flask of reacting material in a constant temperature bath different lengths of time depending on the analyst's interpretation of, say, "allow to come to constant temperature in a 25-deg. bath." Again, if instructions say take a sample of five bobbins at random without specifying how randomness is to be achieved, one person is likely to introduce one bias and another person a different bias. Or, the validity of the test can be seriously affected by small changes in procedure when one analyst, in teaching another, passes on his own little innovations or short cuts.

These and similar considerations lead to the conclusion that, for control, procedures and specifications must be not only written down so that they are not inadvertently changed, but instructions must be very carefully written so that interpretation is uniform. We are convinced at our plant that time spent in clarifying instructions and reducing them to writing saves many fold as much time in looking for elusive troubles.

We have developed four formats for different kinds of procedures. All laboratory manuals are required to conform to the appropriate format. They are shown in Figs. 1, 2, 3, and 4. The "Sample Summary" is intended to be a guide for the technician in taking a sample. The "Equipment Methods" describes how apparatus such as pipettes, balances, and colorimeters are to be used and cared for. The "Preparation Methods" tells how to prepare reagents. And the "Analytical Methods" gives directions for making the analysis or test.

Most of our analysts are high school graduates. Therefore, in writing methods we try to aim the language at their level, explaining all terms which would not be familiar to them, and taking into consideration their contact with usual laboratory apparatus. We find that this simple style of writing helps

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chemists, engineers, and foremen as much as it does the technicians. When a procedure is edited the criterion used to judge it is: Could a trained analyst justify an interpretation other than the one intended?

After instruction, analysts must be checked on a continuing schedule to see that they do not deviate from the established procedure. One way to do this is to actually watch them as they do their work, comparing what is seen with the written instructions. This is a necessary thing to do, but, as you know, "the proof of the pudding is in the eating." Therefore the most important thing to check is the result.

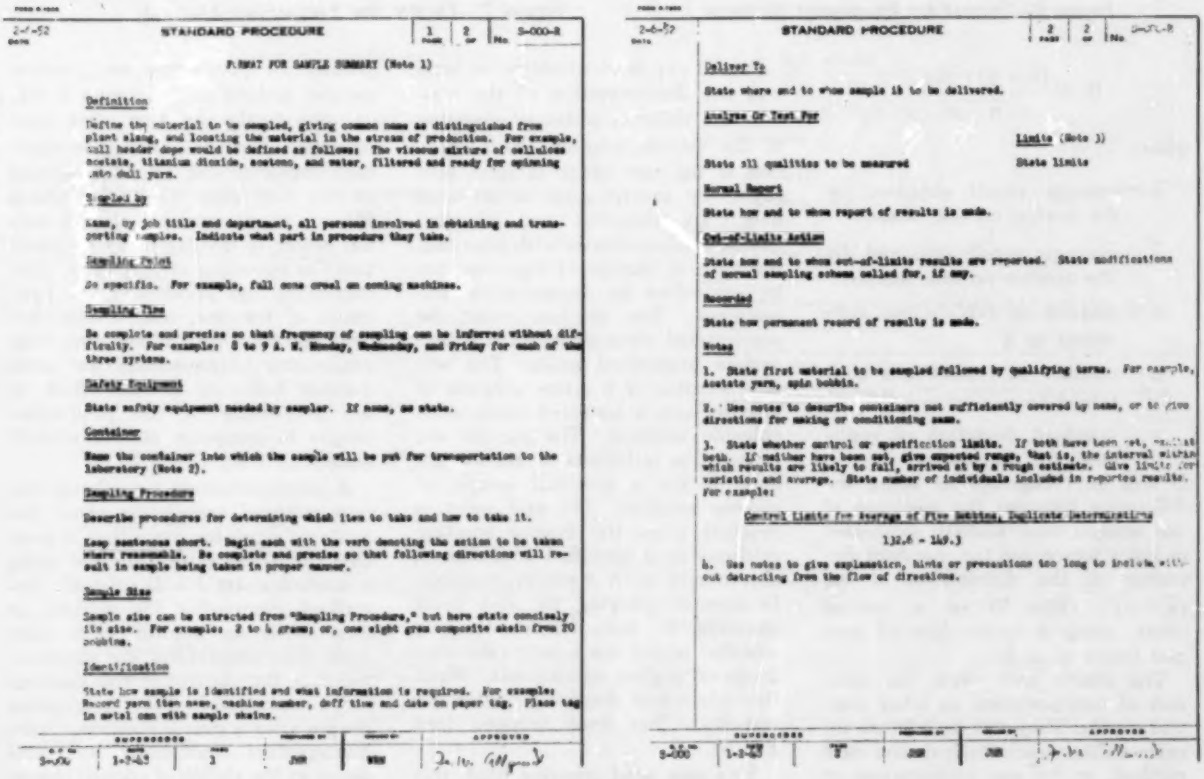
To check the results of a test one usually longs for a standard sample which seldom, if ever, is at hand, or for that matter which can rarely be obtained. Take, for example, the testing of yarn for strength. I know of no supply of a standard sample or of how to prepare one. Consider also a yet more difficult situation where a mixture still in the process of reacting must be tested to determine how far the reaction has progressed. This difficulty of not being able to obtain a standard sample can be overcome satisfactorily in a control laboratory by a method described here.

Suppose that a satisfactory standard sample is available with the quality characteristic of interest known. One could disguise the sample by coding the identification, and submit it to the technician for analysis along with his normal routine samples. Then a comparison of the reported and known values could be made. It is the opinion of those of us in charge of the laboratories at our plant that this is a very poor practice. We never do it. It is poor because we would be deceiving the analyst in that we would be telling him that the sample is one thing when in reality it is another. We want him to play fair with us, so we must play fair with him. Even though you warn the analyst that this may be done from time to time, it still bears a taint of deceitfulness. You cannot avoid the fact that you not only must trust the analyst, but also are almost completely at the mercy of his integrity. Since the only way to make a man trustworthy is to trust him, we do just that.

Checking can be put on another basis, and be given a different tone. Tell the analyst that you are going to check his work at odd intervals. Tell him that while you trust in his honesty, checking is necessary because even though he does not want to allow it to happen, he may inadvertently change his technique, or his equipment or reagents may change.

Select a person to be designated as auditor. Have this man run the same test on the same material as the analyst to be checked using the routine samples. The times at which the two runs are made may or may not be the same, depending on the nature of the material involved and convenience. The frequency of checking should be determined by the same considerations as any other sampling scheme.

Compare the results obtained by the two men using the following statistical technique. Compute the statistic



STANDARD PROCEDURE

FORMAT FOR SAMPLE SUMMARY (Note 1)

Definition

Define the material to be sampled, giving common name as distinguished from plant slang, and locating the material in the stream of production. For example, "All header dope would be defined as follows: The viscous mixture of cellulose acetate, titanium dioxide, acetone, and water, filtered and ready for spinning into dull yarn.

Sampled by

Name, by job title and department, all persons involved in obtaining and transporting samples. Indicate what part in procedure they take.

Sampling Point

Be specific. For example, full cone creel on coning machines.

Sampling Time

Be complete and precise so that frequency of sampling can be inferred without difficulty. For example: 8 to 9 A. M. Monday, Wednesday, and Friday for each of the three systems.

Safety Equipment

State safety equipment needed by sampler. If none, so state.

Container

Name the container into which the sample will be put for transportation to the laboratory (Note 2).

Sampling Procedure

Describe procedures for determining which tiers to take and how to take it.

Keep sentences short. Begin each with the verb denoting the action to be taken where reasonable. Be complete and precise so that following directions will result in sample being taken in proper manner.

Sample Size

Sample size can be extracted from "Sampling Procedure," but here state concisely its size. For example: 2 to 4 grams; or, one eight gram composite skein from 20 cookies.

Identification

State how sample is identified and what information is required. For example: Record yarn item name, machine number, doff time and date on paper tag. Place tag in metal can with sample skeins.

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S-000 | 1-2-52 | 1 | JSH | WBH

STANDARD PROCEDURE

Deliver To

State where and to whom sample is to be delivered.

Analyze Or Test For

Limits (Note 3)

State all qualities to be measured | State limits

Normal Report

State how and to whom report of results is made.

Out-of-Limits Action

State how and to whom out-of-limits results are reported. State modifications of normal sampling scheme called for, if any.

Recorded

State how permanent record of results is made.

Notes

1. State first material to be sampled followed by qualifying terms. For example, Acetate yarn, spin bobbin.

2. Use notes to describe containers not sufficiently covered by name, or to give directions for making or conditioning same.

3. State whether control or specification limits. If both have been set, [illegible] both. If neither have been set, give expected range, that is, the interval within which results are likely to fail, arrived at by a rough estimate. Give limits for variation and average. State number of individuals included in reported results. For example:

Control Limits for Average of Five Bobbins, Duplicate Determinations

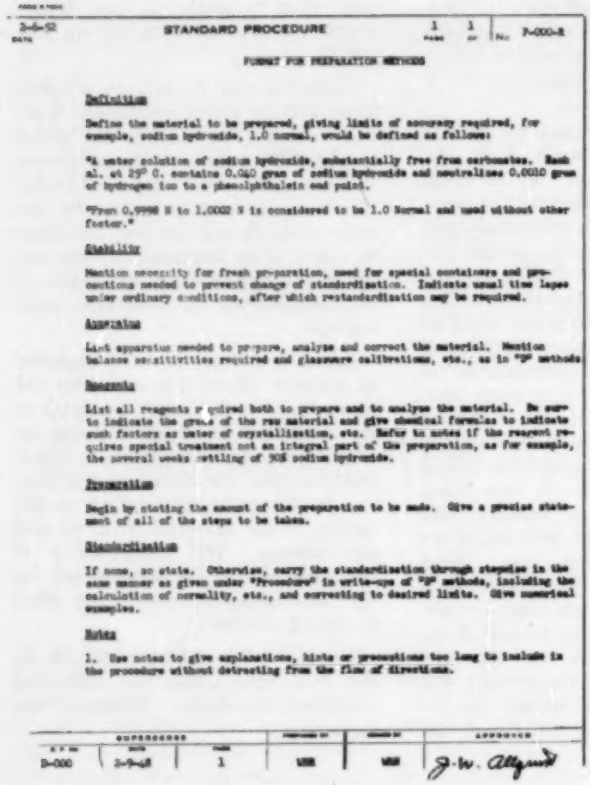
132.6 - 149.3

4. Use notes to give explanation, hints or precautions too long to include without detracting from the flow of directions.

SUPERSEDES | APPROVED

S-000 | 1-2-52 | 2 | JSH | JSH

Figure 1—Format for Sample Summary



STANDARD PROCEDURE

FORMAT FOR PREPARATION METHODS

Definition

Define the material to be prepared, giving limits of accuracy required, for example, sodium hydroxide, 1.0 normal, would be defined as follows:

"A water solution of sodium hydroxide, substantially free from carbonates. Each ml. at 29° C. contains 0.040 gram of sodium hydroxide and neutralizes 0.0010 gram of hydrogen ion to a phenolphthalein end point.

"From 0.9998 N to 1.0002 N is considered to be 1.0 Normal and used without other factor."

Stability

Mention necessity for fresh preparation, need for special containers and precautions needed to prevent change of standardization. Indicate usual time lapse under ordinary conditions, after which restandardization may be required.

Apparatus

List apparatus needed to prepare, analyze and correct the material. Mention balance sensitivities required and glassware calibrations, etc., as in "P" methods.

Reagents

List all reagents required both to prepare and to analyze the material. Be sure to indicate the grade of the raw material and give chemical formulas to indicate such factors as water of crystallization, etc. Refer to notes if the reagent requires special treatment not an integral part of the preparation, as for example, the several weeks settling of 50% sodium hydroxide.

Preparation

Begin by stating the amount of the preparation to be made. Give a precise statement of all of the steps to be taken.

Standardization

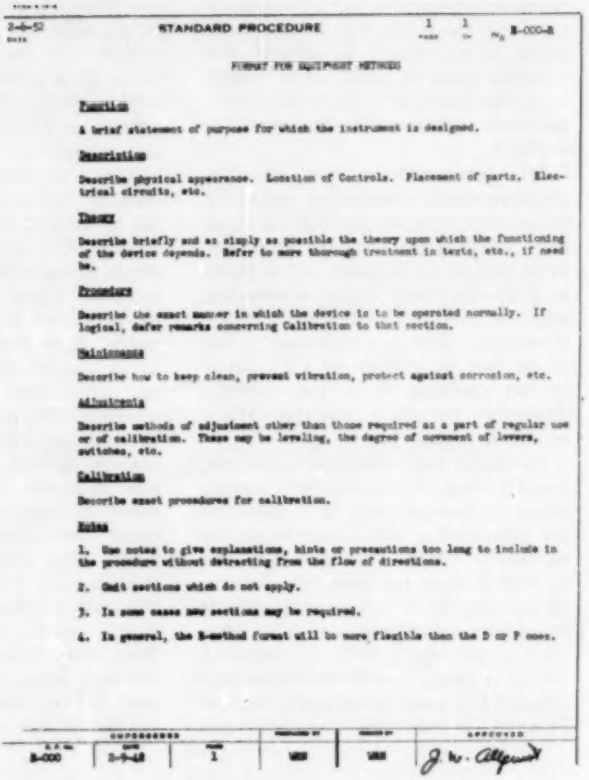
If none, so state. Otherwise, carry the standardization through stepwise in the same manner as given under "Procedure" in write-ups of "P" methods, including the calculation of normality, etc., and correcting to desired limits. Give numerical examples.

Notes

1. Use notes to give explanations, hints or precautions too long to include in the procedure without detracting from the flow of directions.

S-000	2-9-48	1	WEB	WEB	J. W. Allgood

Figure 3—Format for Equipment Methods



STANDARD PROCEDURE

FORMAT FOR EQUIPMENT METHODS

Function

A brief statement of purpose for which the instrument is designed.

Description

Describe physical appearance. Location of Controls. Placement of parts. Electrical circuits, etc.

Theory

Describe briefly and as simply as possible the theory upon which the functioning of the device depends. Refer to more thorough treatment in texts, etc., if need be.

Procedure

Describe the exact manner in which the device is to be operated normally. If logical, defer remarks concerning Calibration to that section.

Maintenance

Describe how to keep clean, prevent vibration, protect against corrosion, etc.

Adjustments

Describe methods of adjustment other than those required as a part of regular use or of calibration. These may be leveling, the degree of movement of levers, setting, etc.

Calibration

Describe exact procedures for calibration.

Notes

1. Use notes to give explanations, hints or precautions too long to include in the procedure without detracting from the flow of directions.

2. Omit sections which do not apply.

3. In some cases new sections may be required.

4. In general, the E-method format will be more flexible than the S or P ones.

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Figure 2—Format for Preparation Methods

$$D = \frac{(\bar{x} - \bar{y})\sqrt{mn}}{\sigma\sqrt{n + m}}$$

where

$\bar{x}$ = average result obtained by the analyst on one sample

$\bar{y}$ = average result obtained by the auditor on one sample

m = number of replications contained in $\bar{x}$

n = number of replications contained in $\bar{y}$

σ = standard deviation of replicates for the method

D will be recognized as being the difference between the averages of the analyst and auditor expressed in units which are the standard deviation of the distribution of the $(\bar{x} - \bar{y})$'s. Plot D on a control chart, using a center line of zero and limits of $\pm$ 3.

The charts will allow the same sort of interpretation as other control charts. They can be plotted for each auditor, each analyst, and each method, or for any combination or breakdown that is meaningful.

One of our most troublesome tests was the determination of the ammonium chloride index of ripeness of the viscose solution. This solution is the one which is spun into rayon by precipitation in an acid bath. Its chemical and physical characteristics change with time, but the rate of change of ripeness can be controlled by temperature adjustment. The solution must be precipitated when its index is within certain prescribed limits. The test is a titration of a dilute solution of viscose with a standard ammonium chloride solution. The results are reported in milliliters of ammonium chloride for a specified weight of viscose solution. The end point is reached when the viscose solution thickens to a specified consistency, determined in a specified manner. In essence, judging the end point amounts to the analyst deciding whether or not the solution flows or drops off a glass stirring rod. When flow stops and dropping begins the end point has been reached (see Fig. 5).

You can well imagine that this test would provide a splendid battle ground for production and control people. Indeed in times past it did, and the battles were of some consequence because when the ripeness index is out of specifications on the low side, discarding about $65 worth of viscose solution into the sewer is involved, not to mention the upsetting of schedules. Determining and publicizing the precision of the test, and a one-time demonstration that all analysts were performing in essentially the same manner had only a little effect on the propensity of the production people to complain about "wrong" results.

A combination of two things has now silenced complaints about the analysts' work for more than a year. One thing was setting up and using a control chart for D, already described, comparing the analyst on duty with an auditor once each shift. The other thing was improvement in the control of the ripeness index accomplished by production people after a strong statement from management reaffirming its confidence in the ability of control charts, long since established, to describe

the limits within which it was possible to maintain the index.

The ordinary control charts for production are also of great worth in controlling the laboratory. Their value in this respect should not be overlooked. Following is a description of an experience which illustrates this point.

To determine the concentration of cellulose acetate in acetonic dope (the mixture from which acetate yarn is spun by precipitation in hot air), a small amount (weighed by difference) of dope is squeezed out of a tooth paste tube onto a hot plate similar to a sandwich toaster. The flat cover is quickly lowered; the dope is thus dried for a predetermined length of time; when the cover is raised a small wafer of cellulose acetate is ready for immediate weighing.

The set-up for doing this (see Fig. 6) includes two balances. The one on the right is specially fitted for weighing toothpaste tubes. The one on the left is specially fitted for weighing hot wafers. Each balance has a stool in front of it. In between the two balances is located one hot plate with four separately hinged covers.

These analyses are run in duplicate at irregularly spaced intervals about four times per shift, three shifts per day, seven days per week. This work is confined to four analysts. Averages of the duplicate runs on individual samples and ranges of the duplicates are plotted on control charts.

It was noticed on the range charts that occasional points were falling out of limits. This could have been caused either by poor mixing of the dope or by errors in the analysis. On investigating, the charts were replotted, plotting one chart for each analyst. Analyst A's chart showed him to be biased toward the high side for both the range and the average. It was also noticed in recomputing and listing his range of duplicates that his first run was on the average higher than his second run. Statistical significance of this was demonstrated by the sign test. All four charts, coded to disguise names, were shown to the analysts, telling each one his own code name. The situation was explained to them

Figure 5—Ammonium Chloride Index End Point

and they were asked to help in finding the trouble.

They were not long in coming up with the answer. The hot plate had become warped in use, and wafers dried on the second position from the right were thicker than wafers from the other three positions. This extra thickness, by allowing some volatile matter to remain in the wafer, was enough to make determinations made on this position higher, on the average, than the

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FORMAT FOR ANALYTICAL METHODS (Note 1)

Epitome

A brief description of the fundamentals of the method, together with definitions of such items as viscosity, heat stability, etc., which lack meaning if not defined.

Include chemical equations where feasible.

State basis of figures reported, i. e., "Results reported as % sulfuric acid by weight".

Apparatus

List all apparatus by name and size or kind
Balance, 4-place
Buret, 50-ml., calibrated
Graduate, 2-liter
Pipet, 10-ml.
Special absorption bulb (Note 2)

Reagents

0.1 N sodium hydroxide (P-xxx)
1 N sulfuric acid (P-xxx)
Dilute hydrochloric acid (P-xxx)
Somebody's reagent (must be freshly prepared). (P-xxx).

Procedure

Keep sentences short. Begin each with the verb denoting the action to be taken, where reasonable. Paragraph at logical points in the procedure.

Refer to notes (Note 3).

Indicate required accuracy of weighings and other measurements, as "Weigh approximately 2 grams to 0.001 gram".

Be complete and precise, so that exact following of directions will result in the analysis being properly performed.

Refer to H numbers for proper manipulation of instruments such as colorimeters, density balances, etc.

Calculations

Define symbols and show formula in full, followed by simplified formula, if any. Refer to changes in calculation constants if unusual samples may require them. Always include a numerical example. If no calculations, so state. Substitute "Interpretation" if the method requires it. A typical arrangement:

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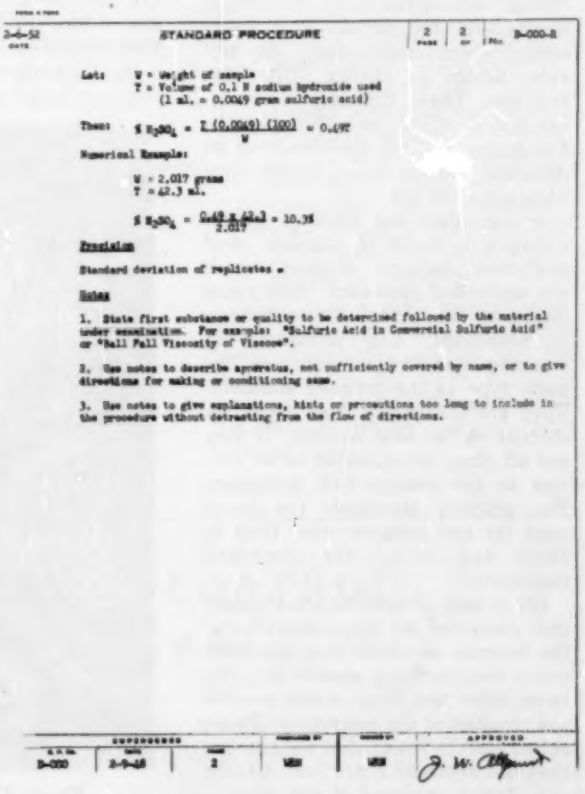

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Let: W = weight of sample
T = Volume of 0.1 N sodium hydroxide used
(1 ml. = 0.0049 gram sulfuric acid)

Then: $\% H_2SO_4 = \frac{T\,(0.0049)\,(100)}{W} = 0.49\frac{T}{W}$

Numerical Example:

W = 2.017 grams
T = 42.3 ml.

$\% H_2SO_4 = \frac{0.49 \times 42.3}{2.017} = 10.35$

Precision

Standard deviation of replicates =

Notes

1. State first substance or quality to be determined followed by the material under examination. For example: "Sulfuric Acid in Commercial Sulfuric Acid" or "Ball Fall Viscosity of Viscose".

2. Use notes to describe apparatus, not sufficiently covered by name, or to give directions for making or conditioning same.

3. Use notes to give explanations, hints or precautions too long to include in the procedure without detracting from the flow of directions.

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Figure 4—Format for Analytical Methods

other three. Now the two right-hand positions of the hot plate can be reached while sitting at the right-hand balance, but the two left-hand positions cannot, and similarly for the left-hand balance, only the two left-hand positions can be reached while sitting in front of it. Thus one can sit while weighing and either place on or remove from the hot plate, but not both. If one chooses to sit while weighing and depositing dope onto the plates, he is forced to use the two right-hand positions. This is the habit that analyst A had fallen into. Analysts B, C, and D had adopted the other sitting and standing pattern. Thus almost invariably, unlike the others, analyst A's first run was made on the warped position of the hot plate, making it give a high result.

When the difficulty was discovered, the warped hot plate was replaced by another of a slightly different design, the new design being intended to prevent warping.

CONTROL OF THINGS

In addition to controlling the work of the technicians, the things they work with must also be controlled. Things sometimes seem to have a disaffection for people, and enjoy seeing them confounded. At any rate, things do change with time and use. These changes, of course, can and do affect the results of tests. For proper control, changes must be detected and corrected before they have gone too far.

In our plant the primary weight standard is a set of stainless steel analytical balance weights which are calibrated once each three years for us by the United States Bureau of Standards. Our secondary or working standard weights are the same type as the primary standard. They are checked at least every six months on our best balance. If they are off, they are adjusted to be correct to the nearest 0.05 milligram. The primary standards are never used for any purpose other than to check and correct the secondary standards.

Other sets of weights are checked and corrected to the sensitivity of the balance on which they are used, using the working standards. The beam rider and chain of the balance are checked at the same time. Beam riders may be lowered in weight, but they are replaced if too low. Chains are always replaced if not correct. The frequency of checking weights other than the two standards varies according to their frequency of use and location, but a definite schedule is maintained.

While it is realized that there probably are other systems of controlling the accuracy of laboratory weights which are just as good, this system has proven itself to be satisfactory. It also has two very definite advantages. In routine determinations one does not have to make weight calibration corrections. And neither is it necessary to do all of the weighings for one determination on the same balance.

In the interest of speed and simplicity our standard solutions, as with our weights, are all adjusted to a specified tolerance according to the purpose for which they are to be used. The extra time it takes to do this we think is well repaid in time and errors saved in making corrections on results.

All laboratory instruments are checked on a regular schedule. The schedule for each instrument depends on its likelihood of losing adjustment. For example, serimeters are checked once each week; pipettes used for caustic soda solutions are checked once each two months; and colorimeters are checked each time before use.

In a situation where more than one instrument is used for the same job and where no standard sample is available, control can be handled very nicely by a technique which is illustrated by the following description of how we control our serimeters.

A serimeter is a machine used for breaking yarn in order to determine its strength and elongation. Among these machines in our laboratory are six of the pendulum type (see Fig. 7). All six are the same make, but not all are the same model. The problem is to adjust and maintain these machines in such a manner that they are interchangeable in use.

There was a time when work on one machine was not comparable with work on any of the others. Research begun on one machine had to be carried through to completion on the same machine, and each type of yarn was assigned to one particular machine for routine control testing. As can be imagined, this was a very inconvenient and sometimes very embarrassing situation. But the problem has been satisfactorily solved, so that the machines are now interchangeable.

Serimeters are checked each Friday morning. They are checked for speed of descent of the lower yarn clamp, distance between the yarn clamps, level, and dead weight indication on the quadrant scale. If any of these characteristics are not

Figure 6—Set -up for Cellulose Acetate Concentration in Dope Determination

within specified limits, proper adjustments are made to bring them back in.

It would seem that these checks and adjustments would be sufficient to insure that all machines would behave in essentially the same manner, but such is not the case. Even though two machines indicate the proper weight in a static condition, they may very well not give the same result when breaking yarn from the same source. Therefore, the machines are checked further by actually making tests on selected yarn, comparing the results by plotting on a control chart. The comparison is accomplished in the following manner.

One two-pound bobbin of dull acetate continuous filament yarn is selected for use. This is enough yarn to last for almost a year and a half of weekly checking. Using yarn from the same bobbin each week assures having yarn from the same source, but of course nothing can assure having the same yarn since once broken in testing it cannot be broken again. Worse still is the fact that yarn strength and elongation depend on the yarn's moisture content which in turn is dependent on the temperature and humidity of the surrounding atmosphere, plus the length of time it has been in that atmosphere, plus the direction in which the current atmospheric conditions are tending to change its moisture content. Even though the laboratory's atmosphere is held relatively constant and even though the same bobbin of yarn is used, over eighteen months the yarn strength and elongation vary throughout the bobbin more than can be explained by the variation in consecutive individual tests made in one short period of time.

Five determinations are made on each of the six machines. The averages and ranges for each machine

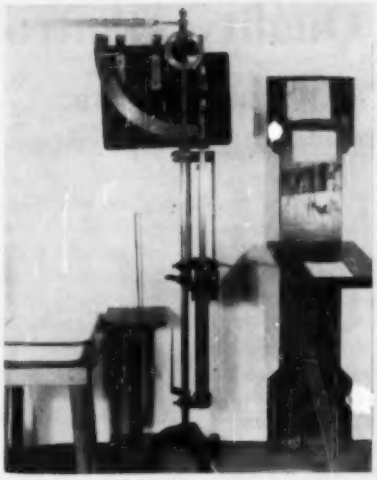

Figure 7—Pendulum Type Serimeter

for strength and elongation are plotted on the same control charts with the following limits. For the range chart, the centerline is $K_1\overline{\overline{X}}$, where $\overline{\overline{X}}$ is the grand average of all 30 determinations and $K_1=\sigma'/\overline{X}'d_2$, σ' and $\overline{X}$ having been previously determined for the bobbin of yarn in use and each machine contributing equally to their determination: the limits are zero to $K_2\overline{R}$, where $K_2 = \sigma' D_2/\overline{X}'$. For the average chart, the center line is $\overline{\overline{X}}$; the limits are $\pm K_3\overline{R}$, where $K_3 = A\sigma'/\overline{X}'$. The constants K_1, K_2 and K_3 need to be calculated only one time for each bobbin, but center lines and limits must be calculated each time a comparison is made.

If a machine is out of limits, it is taken out of service and repaired. Before it is allowed to return to service, ten determinations are made on it and the range and average of these ten tests are required to fall within limits computed as those in the preceding paragraph except that $\overline{\overline{X}}$ is now taken to be the average of the remaining five machines, the constants D_2, A, and d_2 being changed for ten individuals instead of five as before. In this way we can be assured that all of our serimeters are performing in essentially the same manner. When one does fail we can single it out. And we can prevent its being returned to service, if it has not really been brought into agreement with the other machines.

SUMMARY

Control laboratories provide a service, but an analogy can be drawn between the results they report and the goods the factory produces. Both must satisfy and gain the confidence of the customer, in the laboratory's case the production division. The control division should practice what it preaches. It should supply results at the required quality level, that is, required accuracy, and with consistency, that is, in statistical control. Very much the same measures are required of the laboratory as are required of production. They are:

1. Clearly written instructions
2. Scheduled checking of analysis and equipment
3. Use of statistical techniques to detect assignable causes of variation in analytical and testing procedures
4. Correction of equipment, analysts, or instructions when statistical analysis indicates the necessity

While the quality control engineer's job is to help production make acceptable product for less money, let us not allow ourselves to be discovered in the position of the cobbler whose children were without shoes.

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The Role of Quality Control in Industry

HARRY G. ROMIG

International Telemeter Corporation

It is a privilege and an honor to be selected as the Shewhart Medalist for 1953. I sincerely thank the American Society for Quality Control and its members for placing their trust in me in this fashion. I hope that this faith will always be justified.

This occasion gives me an opportunity to present to you some views concerning the role of quality control in our industrial economy. The future offers almost limitless opportunities for applications of our scientific approach. Our quality control group possesses the new approach that will aid our nation in its economic, social, industrial and peaceful development. This unique position demands the utmost in teamwork with others to guide intelligently all the mysterious industrial and economic forces that may affect the future destinies of this society.

To many of us progress is merely motion. The main thing is to keep going—without any particular thought as to plan and purpose. We may be too much like the camper who, having made his coffee, ran out of fuel. He lit a fringe of dry grass and held his frying pan over the moving blaze. The eggs cooked elegantly—but he found himself a mile and a half from his coffee.

It is apparent from the year by year growth of our Society that we have a purpose and a plan and do not move forward without some basic analysis of the reasons for our activities. Looking backward over the years since 1921 when Dr. Walter A. Shewhart enunciated the first principles of quality control in manufacturing processes, it is apparent that his original concept has been extended, encompassing a much broader field. Management has found itself a scientific tool which is applicable in many varieties of activities. It has made use of that tool and found it good. However, it is a duty of those working in this field to present to the many young engineers who are eager to push our frontiers ahead, the basic philosophies underlying the scientific application of quality control principles. They must be advised of the broader concepts developed in local ASQC section meetings, by regional conferences and by national conventions. Dr. Shewhart in his 1938 Washington lectures to the Graduate School of the Department of Agriculture, and in addresses in Great Britain, India, and to the United Nations has expressed these ideas. This discussion will center about the broader role that management desires those in quality control to play in our national economy.

QUALITY MINDEDNESS

The control of quality goes back to the beginning of time. Pride in workmanship existed among the craftsmen of the Middle Ages. The world has a heritage of culture, works of art, and better conditions of living that stem from the desire of mankind for perfection. The process of standardization must not be carried to such an extreme that the world loses the creative artist.

The 1953 Shewhart Medalist Harry G. Romig

Quality is desired in all things. Without Quality Mindedness, pride of workmanship and ownership may be lost. An economy of mediocrity is not desired. This ceaseless urge for perfection by all, particularly the engineer, results in a better standard of living for all.

The principles of statistical quality control embody the applications of the scientific method to all phases of our industrial life including management, research and development, purchasing and vendor relations, plant evaluations, production engineering, inspection, test, accounting and industrial relations. It takes certain of the operations research techniques used by the military and develops scientific teams that are considered by many managements as their most valuable adjuncts.

DETERMINATION OF FIELD OF ACTIVITY

In starting a new business or revitalizing an old established concern, consumer desires must be determined. These demands may be for personal, industrial, or military use. Market research on a scientific basis must be conducted and tied in with the other operational phases. These techniques have been developed using questionnaires, house-to-house visits, and analyses of customer demands. The quality engineer should be so well acquainted with his area that he adds to these market analyses his knowledge of quality standards, production and distribution costs, levels of performance, lead time required for delivery, and relationships between various lines of product. Only then will the findings of the expert market analyst be re-oriented in line with our total national economy. These findings should be subjected to all possible tests to determine in broad terms the resultant effect of various courses of action. The techniques of "operations research" should be applied and management should be provided with various courses of action, including the weighting factors used in evaluat-

ing both the tangible and the intangible operators. Here, the term operator is used in its functional sense.

The task as outlined above is not simple and many errors in judgment will enter. These errors must be minimized. Projected sales, costs, etc. should not be given in terms of a single estimate but as a band. The notion of a confidence interval should be interjected into these reports.

Having provided various objectives and the probable resultant effects of decisions and policies, the business now has established a definite goal. First, it sets up the limited field of activity in which it plans to work. It determines the nature of its competition and where such exists. It also evaluates wherein the company is strong and weak and possible ways of curing the weaknesses. The company then determines its area of activity and the price range for its products within which it deems itself most fitted to operate. It will set up or reorganize those divisions and departments found to be most effective in this effort.

BREADTH OF ORGANIZATION AND AIMS

The next step in these operations is to obtain a suitable organization in which to function most effectively. The quality group is an over-all liaison organization whose function is to co-ordinate the outlying activities and coalesce them into an integral whole. It must be placed in a strategic position in the company's organizational structure so that it can work effectively. Each group, accounting, engineering, research and development, production, sales, etc., strives to develop an independent structure. These various departments develop their functions to their utmost capacity, many times assuming the duties and responsibilities of other groups. An unbiased evaluation of these activities is a necessity for an efficient management. This is one of the most important functions of a good quality engineering organization.

It is only recently that the scientific approach has been recognized as being desirable for application to concrete industrial problems. It was a part of research and philosophy, but experience was considered the best means of maintaining operations and controls and of achieving success. The early workers in quality control, such as Shewhart, Edwards, Dodge, Bartky, Molina and Juran in the United States; Karl and Egon Pearson, "Student" —pen name of W. S. Gossett, R. A. Fisher and Tippett in England; and later Simon, Olmstead, Ott, Collier, Wilks and Tukey here, to name only a few, had to contend with old fetishes. Your production manager was extremely close to his operations and intuitively felt that he was always controlling his quality. He had been controlling the quality of his products for years at such levels that the merchandise was seemingly satisfactory as few people complained. He felt that these young quality control engineers could not tell him how to run his plant. Hence, unless shown otherwise, the production manager would do everything possible to maintain the status quo. He honestly believed that the suggested quality control programs, if placed into effect, would be very harmful. To some extent he was right as in the early stages of quality control many novices, so-called eight-day wonders who had only taken one eight-day course in quality control, expended huge sums of money for fancy charts and programs and achieved no controls and no savings.

The problem became clear. Production must have tangible evidence that the proposed quality control programs would be helpful and also profitable. To achieve improvement in quality, standards must be set, means for evaluating quality must be provided, but above all management must be shown in actual practice that spending money on quality control in any area results in a substantial profit, greater than would be obtained otherwise. This proving of savings and profits from quality control was a difficult thing to do, hence offered a basic challenge to the quality engineer. So many intangibles had to be evaluated that could not be provided with a dollar sign. Goodwill of customers is valuable, but how can it be evaluated. A few cases did show in concrete terms a substantial decrease in rejected materials, an increase in workers' earnings, and an increased profit. Case studies were published showing some of these facts. The American Society for Quality Control was formally organized in February, 1946 bringing into one fold a large number of small local societies that had been operating autonomously for some time previous. The National group had as one of its prime objectives the selling to management the fact that quality control when properly installed would result in substantial benefits, including profits. Some managements took these ideas on faith and obtained such excellent results that more and more of the better engineers were attracted to this field. The military also put their shoulder to the wheel and demanded that industries put in satisfactory quality control systems. Many companies are demanding distributions of inspection and test results with their purchases. The movement towards better controls and more reliability has gotten under way. It must be emphasized, however, that only a small degree of progress has been made. Events on the side enumerated below bear this out.

MOVEMENTS RELATED TO QUALITY CONTROL

In engineering and manufacturing the efficiency engineer appeared the early part of this century, made some progress, but faded away. At one of the leading universities in this country technocracy was advocated; it attempted to provide methods and techniques whereby control of the nation's economy might be taken over by engineers. The thought behind this movement was that the engineer had developed means for devastating war but had established no controls. Herbert Hoover tried to apply engineering principles in government, essentially sound, but not devious and rapid enough to compete with the politicians. Yet his philosophies are still being used today and his counsel is sought and followed by those in high places.

The military desired scientific solutions to highly complex problems arising during World War II. It developed the notion of operations research wherein teams of specialists in extremely diverse fields merged their knowledge to obtain solutions and recommendations for the best and most efficient military operations. This approach proved highly successful. These teams were termed operations research groups. Today separate operations research departments are being added to some of the universities and also are being established in some of the larger industries in this country. This field encompasses the application of the scientific method to

management problems. It may take over quality control, or again quality control in its broader aspects may take it over. Some universities and industries set one portion of this field aside and call it scientific management to point out the lines of cleavage between its truly management functions and those covered by quality control. This pattern may eventually prove best.

Another group which desires to take over many of the functions of quality control is that of industrial engineering. These engineers are breaking away from time and motion studies, are making use of work sampling techniques, linear programming, etc., and feel that quality control should be a portion of their bailiwick. In many industries the industrial engineering department is the central liaison group.

The fact that these various movements have developed indicates a demand for engineering knowledge in areas that have not been covered by other groups. Within these engineering environments the quality control groups must work, broaden their field, and find a means to unite the varied organizations which exist in each company to avoid costly duplication of effort and also costly struggles for power and supremacy.

RELIABILITY

Another problem arises which is being emphasized by the military because of our defense problems although it has long been recognized by industry. That is the concept of reliability. To achieve the ultimate in defense it is necessary to have reliable weapons of offense and defense. Consequently, reliability must be built into components, then into sub-assemblies, then into assemblies to obtain reliable systems. A demand for the systems approach has arisen. Conferences on reliability have been held with little accomplished because, although all desire this reliability feature, no one knows just how it is to be obtained without prohibitive costs. Reliability committees and departments are being organized. Steps are being taken to install reliable quality control systems in the plants manufacturing components.

TECHNIQUES FOR OBTAINING RELIABILITY

The heart of the quality control system is the application of the scientific approach to all aspects and developments that affect quality. No restrictions should be placed on its field of endeavor. Its function is stated tersely in the first paragraph of the Philco Quality Control Manual: "The Quality Control Division shall function independently of the Production and Engineering Departments, and shall have the responsibility of carrying out the Management policy of producing products of the highest quality."

Manufactured products are generally the first to be considered. Any results of human endeavor that increase quality in our national economy, however, are in its field. Shrewd managements are noting this and are coalescing these various activities so that one group alone has the responsibilities. This provides the necessary central controls so that chaos does not exist in the corporate whole. The number of managements that think along these lines is small. Only when the quality control groups can prove that they are capable of handling these broader problems will they be given this opportunity. What can our American Society do to develop men with the broad outlook required for this prodigious task? What elements are lacking in our present outlook that cause the majority of managements to add other elements to their structures to cover the derelictions of quality control?

Another technical approach for obtaining reliability is now entering the picture. In the late 18th Century the industrial revolution occurred. Industry is now to enter the automation revolution. Push-button warfare has been discussed, also push-button production. It is hoped that this concept can be expanded and developed so that we feed in raw materials to a machine controlled by tapes and electronic equipment, which work, test, inspect, rework, and eventually produce reliable products of the highest precision. It has been done in practice with alarm clocks and resistors as well as steel plate in the huge rolling mills. Electronics has a challenge to develop the necessary controls to achieve this end.

Technically quality control's position is fairly sound. The precept of Lord Kelvin: "When you can measure what you are speaking about and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind," has been followed in most test areas. On the other hand, our errors may be so great that we may be in the position of Robert Hues, who wrote in 1592 in London in his Tractatus de Globis, "In this so great a diversity of opinions concerning the true measure of the earth's circumference, let it be free for every man to follow whomsoever he please." You believe that this condition cannot exist today?

Consider then Edward Shanks' statement in the Sunday Times of London 10 February, 1946: "Fortunately I learned a good many years ago that mathematicians are not always the strictly accurate creatures of popular belief. Being in Paris, I developed a cold, and fearing a high temperature, bought a thermometer, which was naturally marked on the Centigrade scale, assuming that my companion, who had taken a first class in the Mathematical Tripos, would be able to translate it into Fahrenheit for me. When I asked him to do so he looked a little dubious, but sat down with pencil and paper. At the end of half an hour, he presented for my choice a variety of results, ranging from 93 degrees to 108 degrees F."

The equations may be known but if the methods of using these relations are not fully recognized, the results may be as inaccurate as the temperature results noted above. Testing equipment provides the quality control engineer with findings that are assumed to be correct. The final conclusions are no better than the accuracy of the recorded results used for analysis. Hence, unless the study is purely intuitive, it is very easy to draw false conclusions from meager and inaccurate data. Those phases of operations research that may be taken over by quality control depend for their success on applying the scientific method to data whose errors are known. As a result of these analyses management is provided with a variety of possible decisions. As noted by Ibsen in Peer Gynt: "Many paths lie before me; a wise man is known from a fool by his choice." The role of quality control in this area will only be successful if the errors of prediction are known. Such techniques properly used will result in the reliability desired.

PRESENTATION TO MANAGEMENT

In the management area it may be very advisable to carry the notion of confidence intervals. In predicting a market provide minimum and maximum values as well as the expected or nominal value. When analysing and listing estimates of costs, building requirements, inspection and testing needs, as well as production schedules, make charts that are simple but present with a probability sense the range of variation of the estimates. In discussing this matter with various prominent consulting firms in management and engineering, they believe that such bands, rather than expected values only, would prevent many disastrous decisions. The risks would be appreciated and would properly be evaluated before selecting a final course of action.

The fundamental role of quality control is to provide quality in all phases affecting society from the cradle to the grave. This is an extremely broad function and must be hedged a bit. In many cases the controls will be exact, firm and on a line basis. In other instances the controls will be exerted by policy control, possibly by very devious routes in order to win other groups over to the conclusions that a careful analysis of conditions has indicated as best. These analyses will also not be infallible. Others may resist the conclusions drawn because of better data and knowledge within their area of operation. Hence, any bigoted action by a quality control group will tend to destroy its usefulness. Diplomacy of the highest type must be used. In all instances the position of the design engineer, the production foreman, and others must be carefully considered. Many errors of judgment may be eliminated by delaying action until more data are obtained. It must be remembered that, as noted in Ecclesiasticus 20:18: "To slip upon the pavement is better than to slip with the tongue." The old adage, "Your faults will find you out," must be recognized. The quality control engineer is in an enviable position to assist in the guidance of the destinies of his concern. He must recognize the importance of this task and never make a hasty and unwarranted decision.

FUNDAMENTAL RESEARCH IN QUALITY CONTROL

Today the many papers that are presented at conferences and conventions are merely rephrasing the fundamentals developed many years ago. A purely original paper is a rarity. It should be part of any integrated quality control program to provide some appreciable time for fundamental research. This will pay off in the long run. It is hoped that this will be very soon one of the fundamental roles in quality control, at least in the larger industrial concerns.

This development and presentation must not be a rehash in different words of old truths, methods and techniques. Illustrating this point there comes to mind the story of the sick man who recently visited his doctor for a check-up. The doctor made a thorough check and informed him: "All that's the matter with you is that you've been drinking too much." The patient nervously stated: "Well, that may be, but I can't inform my wife of this diagnosis." "Oh," said the doctor, "just tell her you're suffering from syncopation." This pleased the patient and he had the doctor write this diagnosis on a piece of paper to give to his wife. However, the wife was quite shrewd. She immediately went to the dictionary to determine the meaning of syncopation. She found the definition that applied: "Irregular movement from bar to bar."

Whether the company which the quality control engineer is with is large or small, the framework within which he works is similar. Management demands of his group a proper evaluation of those activities for which he is held responsible. Information must be made available as rapidly as possible of those events which guide the destiny of the company. Research has developed a new process. Is it good? Management desires an unbiased answer. Design has provided new mechanisms which they feel should be substituted for the current design. Experiments must be devised for properly evaluating the old versus the new. Again an unbiased view is required. When working closely with any new process, product or activity, the beneficial results are outstanding to those who have suggested the change. Someone must coldly analyse the entire field, survey all possible contingencies for the various possible courses of action and present a clear report of such findings. Hence, the field of design of experiments needs to be entered by quality control and the group must have an expert in this area available for such evaluations. The old techniques may not be applicable, or sufficient, or may prove to be too complicated. Further fundamental research is often required to provide the means to supply management with valid answers. Fundamental research must not be neglected.

FUNCTIONS OF QUALITY CONTROL

In addition to fundamental research and the development of new mathematical, statistical and engineering techniques for obtaining reliable results, quality control has many other functions. Design of experiments has already been mentioned. Those fields now covered largely by production engineering must also be entered. Is the design satisfactory for large-scale production? Do results from the field indicate a satisfactory, adequate and economical quality product? Should engineering changes be proposed? These are pertinent questions which require the best engineering judgment of the group. All recommendations made should be constructive.

The quality control group are members of a team composed of all the elements comprising the company. It is very easy to criticize, to reject, to blame others; possibly the trouble may lie in faulty test gear or a misunderstanding of engineering requirements. Management expects to obtain a fair evaluation of all sides of each proposal. Hence, knowledge must be available covering all the latest techniques and methods for proper analysis. The most difficult part is to so present these findings that all sides of the problem are apparant to management. Summaries must be provided, both graphical and tabular in nature. In some companies a purely statistical group may handle such a function in connection with their handling of other corporate data. Key management personnel must be provided on a regular periodic basis, weekly, monthly, quarterly, etc., with a condensation of the elements for which each executive of the company is responsible.

Complaints and field reports often go directly to engineering, to industrial relations, to a reliability group, or to some separate complaint bureau. Since quality

control is responsible for quality standards, it is necessary that they either handle this field directly or have a very close relationship with those who have been given this function. The establishment and operation of a dynamic complaint group may well be a function of quality control.

To compare, it is necessary to have a standard of comparison. The quality control group is responsible for standards. The notion that a quality group is responsible for "Satisfactory, Adequate, Dependable, and Economical Quality", termed "SADE-Q" by Dr. Shewhart, is not antiquated. It still holds, but many companies fail to recognize this important function. Unless this function is performed properly, however, quality control will be considered a costly adjunct, not a necessary requirement.

In many instances the words "Inspection" and "Quality Control" are treated synonymously. A firm has an inspection group. Its military contract states that it must operate under MIL-Q-5923B, or some equivalent document. The name of the inspection group is changed to quality control, a manual is written, and without any change in its operations it is assumed that now a strong quality control system is in effect. In some companies it is true since inspection has already set up those techniques required for a satisfactory control of product quality; they may even have process controls in operation at strategic inspection stations. Generally only mechanical and visual inspections have been performed with a final acceptance inspection, often only visual in nature. Such an inspection group is usually under the production department, hence may be in no independent position to provide an unbiased evaluation of quality. Sometimes the group is under engineering, and sometimes under the sales or advertising department.

A single form of organization is not advocated. The quality control group must be placed where it will do the most good for the company as a whole. Sometimes it will be organized centrally, being composed of a reliability group, an analysis or operations research group, an inspection group, a test group, a test equipment group, a standards group, and a complaint bureau with a field unit attached. If the quality control director is not fitted for such a broad program, or if the company's functions are of such a restricted type that all these functions are not required, then the organization must be patterned about the business of the company. Thus there will be many variations of this ideal central organization wherein all functions are combined for the most efficient possible operation. In all cases the quality control group must be an independent group responsible directly to top management as affirmed earlier in the Philco Quality Control Manual. It must be on a par with engineering and production. These three groups must provide the company with a strong, co-operative team working together for the company as a whole and not for each separate department alone.

The thought that quality control engineering should be an independent function, the same as production, engineering, and accounting, is not noted in even the most recent texts on management. Electrical engineering, not so long ago, was not recognized as a profession. About 25 years passed before it was considered mature enough to be accepted as a separate engineering group. The same is true of quality control engineering. It is now sufficiently mature to be accepted by management as one of its most valuable aids.

The most successful operations apparently now exist where the independent nature of quality control is recognized. One compromise has been to send products out to independent laboratories for inspection and test to provide management with an unbiased opinion concerning the operation of their various groups. This is usually more costly than setting up a group within the company and, more important yet, does not provide for rapid communication regarding errors in the process so necessary for the reduction of scrap to a minimum.

THE DYNAMIC APPROACH

Reliability and its achievement are one of quality control's prime functions. Constant vigilance is required to maintain the quality demanded by management. Technical advances have been made in automatic inspections. Where pieces are made at high speed, say from 100 to 3000 per minute, inspection becomes the bottle-neck for production unless mechanization is achieved. Sampling provides one answer and a very good one. Many forms of sampling inspection are available. Shainin's Lot-Plot plan has many adherents; Hughes modification of Lot-Plot, termed Lot Template Method of Inspection, developed by Hill and his associates, offers another approach; Crawford's Discovery Sampling by Attributes and by Variables provides protection for lots rather than units; AOQL Sampling Tables, AQL Sampling Tables of various kinds including MIL-STD-105A Tables, Bowker and Goode working at Stanford have a modification of MIL-STD-105A to cover Variables Inspection; Continuous Sampling Plans for Attributes, the more recently developed Continuous Sampling Plans for Variables; Control Charts of all kinds, Demerit Rating Systems, the Classification of Defects according to seriousness and the assignment of Demerit Weights, and the establishment of Reference and Standard Quality Levels—all these provide tools that are available for use by quality control groups.

The weakness in many present systems of quality control is that full advantage is not taken of these excellent techniques. Many new ideas and methods are presented at section and regional meetings and at national conventions, such as this; then the let-down comes later when there is no opportunity for and often definite opposition to the application of these new cost-saving techniques in the operating plant. This is often due to poor internal organization, failure to keep other groups properly informed of all phases of such projected operations, and sometimes due to inertia of old-line organizations. Quality control, inspection, test, reliability, operations research, vendor evaluation, adjudication of complaints, and many other functions of quality control are split in different cells, sometimes allocated to other groups and sometimes entirely forgotten. This destroys its effectiveness. More vision is required, better leadership and, above all, an efficient internal communication system together with teamwork between all divisions and sub-divisions.

THE GOAL OF QUALITY CONTROL

Management places the responsibility for quality products and components in the hands of quality control. Management demands that reliability be built into these components and systems. Quality control should not shirk its duty. It must comply with this dictum of management.

To accomplish its task quality control should demand its birthright, its functions, its responsibilities, together with the necessary authority to achieve its goal. It must perform its functions in line with company policies, take advantage of the assistance that other groups within the company are glad to provide, aid others in their tasks by indoctrinating them in these new statistical techniques, and provide management with those savings so necessary for a profitable business. Its fundamental goal is mutual helpfulness, capable performance of all tasks assigned, alerting management to potential trouble by scientific analyses and forecasts, maintaining communication with all company groups, and keeping its own personnel and others inspired with the spirit of teamwork. This provides and maintains a quality operation in all phases of the company. Doing only part of this task weakens the position of quality control. Its entire kit of tools must be placed at the disposal of management and it must itself become a part of management. Only then will it fulfill its destiny. This is the role that quality control must take in our new industrial revolution.

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4. P. Peach, *An Introduction to Industrial Statistics and Quality Control*, Edwards & Broughton Co., Raleigh, N.C., 1945.
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REPORT OF THE

Eighth Annual Convention American Society for Quality Control

ST. LOUIS, MISSOURI—JUNE 9, 10, 11, 1954

The official program wasn't scheduled to start until 11:00 A.M. on Wednesday, June 9, but word had gotten around of the hospitality being extended by Anheuser-Busch, Inc. and the delegates started rolling in as early as Sunday. By 1:00 P.M. on Tuesday afternoon, over 1,000 people had arrived and were ready for the start of the festivities. At that time, the first bus load departed from the Jefferson Hotel to the Anheuser-Busch Bottling Plant. After a tour of the plant, they were taken by chartered bus to Grant's Farm, the estate of Mrs. August A. Busch, Sr. Here all enjoyed a visit to the Bauernhof where there is kept the famous collection of park and road coaches, gigs, runabouts, hunting wagons, vis-a-vis, phaetons, carts and sleighs that have won admiration from sportsmen the world over. Coaches and sleighs acquired by the Busches from the Vanderbilts and Harrimans occupy prominent places surrounded by the smaller vehicles.

Everyone enjoyed seeing the cabin in which President Ulysses S. Grant lived, which has been carefully preserved as a historical shrine. Some 250 head of deer and numerous buffalo are to be seen everywhere on the preserve. Cast bronze deer stand at the main entrance of the Farm to set the stage for wild animals which swarm the preserve.

Supper was served on the canopied veranda of the Main House and also in the courtyard of the Bauernhof. Music by two orchestras entertained while the guests ate a supper that proved to be a gourmet's delight.

Everyone was completely fascinated when Mr. August A. Busch, Jr. displayed the newest acquisition to the estate—Tessie II, a baby elephant.

The pre-convention social at Grant's Farm was so much enjoyed by everyone that it remained a topic of conversation during the remainder of the convention. The gracious and personal hospitality of Mr. Busch, Mr. Anheuser, and other officials of Anheuser-Busch made this event an outstanding highlight and wonderful beginning for the convention.

Due to difficulty with hotel reservations at past conventions there was some apprehension regarding lodging in St. Louis. To the delight of everyone, the reservations were handled smoothly and very little difficulty was encountered. Although last minute registrations were greater than anticipated, the registration committee was able to maintain the high standard set at past conventions by requiring only a minimum time for each registrant to obtain his material and enter the convention area.

The Kiel Auditorium Convention Hall was ideal for a convention such as this. There is an Exhibition Hall that was more than adequate for handling all the exhibits. The opening assembly was held in the Opera House and luncheons were served in the Convention Hall. Technical sessions were held in the special meeting room.

At 11:00 a.m. Wednesday, June 9, the convention was called to order by Paul K. Leatherman, chairman of the convention committee. After making a few announcements, Mr. Leatherman introduced the Honorable Raymond R. Tucker, Mayor of St. Louis. Mayor Tucker, who is an engineer by profession, welcomed the convention to St.

President Al Davis Presents the Shewhart Medal to Harry Romig

Harold Dodge, Walter Shewhart, George Edwards, Harry Romig.—ASQC's All-Time, All-Star SQC Team

Louis, not only as mayor of the city, but also as one who is interested in statistical quality control. Mr. Leatherman then introduced Mr. E. T. T. Williams, chairman of the board of the Lambert Pharmacal Company, who gave the opening address. Mr. Williams in his address stressed the fact that the international situation will affect our lives most in the future.

After the opening ceremonies, the next test was one of whether the arrangements committee was prepared for the large turnout of 1450 registrants. After a very fine luncheon, everyone was ready to admit that the arrangements committee had made excellent use of statistical techniques and had followed the probability curve with great accuracy.

President Al Davis Congratulates Ed Olds on Winning the Brumbaugh Award.

After lunch, the delegates rolled up their sleeves and went to work. The work, of course, was attending technical sessions where the latest developments in statistical quality control were being presented. Eight concurrent technical sessions were held, the first starting at 1:10 p.m. on Wednesday afternoon and two each on Thursday and Friday.

A social evening was held at 9 p.m. on Wednesday, in the Gold Room of the Jefferson Hotel. The members and their wives enjoyed an old time melodrama, showboat performance of "The Drunkard." The audience delighted in hissing the villain, cheering the hero, and exchanging remarks with the actors. Kort Pfabe and Emmet Boyer of the convention committee provided additional atmosphere by vending peanuts in the audience before the play and between acts. After the play a record number of attendance prizes were given.

Mr. W. H. Martin, Deputy Asst. Sec. of Defense, was the speaker at the Thursday luncheon. He cited the importance of quality control in the production of military items.

At 4 p.m. Thursday the annual meeting of the American Society for Quality Control was held at Keil Auditorium. President A. L. Davis departed from previous practice in conducting this year's meeting. For the first time this year the annual reports of the officers were available in printed form for those desiring them. The report of the tellers committee was the only one presented orally leaving the balance of the time available for answering the questions of those in attendance at the meeting.

The annual banquet was held on Thursday at 6:30 p.m. in the Gold Room of the Jefferson Hotel. Following an excellent meal the 800 persons in attendance heard an equally excellent talk by the guest speaker, Dr. J. O. Christianson. Although his talk was filled with many humorous anecdotes, he also brought a serious note in his presentation of "Our Part in These Times." He outlined the problems that face Americans, both at home and abroad, and made a plea for unity among different creeds, religions, and races.

Paul Leatherman, general chairman of the Eighth Annual Convention, was presented with the Lester Kaufman award for the performance of outstanding service to the St. Louis section. This award, named for the first chairman, is presented annually by the section.

Following this award President Al Davis made the 1953 Brumbaugh Award presentation to Dr. Edwin G. Olds for the best article in Volume IX of Industrial Quality Control. The winning article, "The Place of SQC in an Industrial Organization," was published in the May 1953 issue (Vol. IX No. 6).

President Davis next introduced Harold F. Dodge who served as sponsor for the 1953 Shewhart Medalist. The text of Mr. Dodge's sponsoring address follows:

This evening I have a two-fold privilege, first to give a brief review of the background of the Shewhart Medal, and second, to act as sponsor in introducing to you the Shewhart Medalist for 1953.

The 1954-55 American Society for Quality Control Officers (left to right): Leon Bass, Paul Robert, Art Bender, Ray Saddoris, Mason Wescott, Julian Toulouse, Dorian Shainin.

Incoming President Ray Saddoris with Executive Directors (left to right): Paul Leatherman, Ervin Scheisel, Ray Saddoris, Clarence Burdick, Warren Purcell, Dale Lobsinger.

The story of the Medal dates back to 1947. In June of that year the Board of Directors of the American Society for Quality Control voted to establish the Shewhart Medal, to be awarded "not more than once each year" to an individual who has made a "suitably outstanding contribution to the cause of quality control." The responsibility of selecting a Medalist rests with a special committee designated the Shewhart Medal committee, which consists of nine members, three appointed each year for a three-year term. Not later than six months prior to the date of the Annual Convention of the Society, the chairman of the Shewhart Medal committee writes a letter to all national directors of the Society, inviting them—in consultation with section officers—to submit suggestions to the committee. The national directors are advised to consider all eligible persons, both here and abroad, non-members as well as members of the Society. At the same time, the chairman of the Medal committee invites the committee members to make nominations for the Medalist. All of these names are then formally considered by the committee.

Factors considered in selecting the Medalist are pioneering or contributions in the field of quality control, successful promotion and management of quality control programs, and service to the art and to the Society. In addition to selecting the Medalist, the committee is responsible for preparing the citation and arranging the presentation ceremonies. The decisions of the committee are subject to review by the executive committee of the Society.

The Medal bears the inscription "Awarded for Outstanding Leadership in the Field of Modern Quality Control." Its design in reverse portrays a micrometer emblazoned with a control chart, signifying the taming of rampant manufacturing variations by the art of quality control. The obverse presents a striking likeness of Dr. Shewhart, a truly distinguished work of art by the young artist Robert Weinman. Both the medal and a certificate bearing the citation are presented at the annual meeting of the Society.

My second and pleasant duty is to serve as sponsor for the 1953 Medalist. The Shewhart Medal committee, consisting of Messrs. Arthur Bender, Jr., Martin A. Brumbaugh, Frank E. Grubbs, J. C. Knapp, B. H. Lloyd, Ellis Ott, E. H. Robinson, and myself, under the able chairmanship of General Leslie E. Simon, has accorded me the rare privilege of presenting the man selected as the 1953 Shewhart Medalist: Dr. Harry Gutelius Romig. It is an honor for which I am deeply grateful and which has a special significance to me. The official citation reads as follows:

> "The Shewhart Medal, established by the American Society for Quality Control for outstanding leadership in modern quality control, awarded to Harry Gutelius Romig for the year 1953 in recognition of his contributions to the early developments of statistical quality control, his achievements in the development of widely adopted standard tables for sampling inspection, and his invaluable service to others as teacher, guide, and friend in promoting the understanding and use of quality control methods from coast to coast."

Harry Romig was born at Lawson, Missouri. He received his A.B. degree with honors in mathematics at Pacific University in 1921, his A.M. degree at the University of California in 1923 and his Ph.D. in industrial engineering at Columbia University in 1939. Following two years as a teaching fellow in physics at the University of California, and two years as an instructor in mathematics and physics at San Jose Teacher's College in California, he came to the Bell Telephone Laboratories in 1926 as a member of the technical staff, just two years after the new Quality Assurance Department, then called Inspection Engineering, was organized. This group, with Dr. R. L. Jones as director, included Dr. Walter A. Shewhart, for whom the Shewhart Medal has been established, Mr. George D. Edwards, the first president of our Society, and other besides myself. You will appreciate why I say this occasion has special significance to me when I tell you that for the next 25 years Harry and I worked closely together in developing and reducing to practice some of the statistical tools used in sampling inspection and quality control.

Perhaps the best-known output of our joint efforts are the Dodge-Romig

Outgoing President Al Davis Presents Incoming President Ray Saddoris with Gavel and Block Made from Joe Adcock's Bat.

Sampling Inspection Tables covering both single sampling and double sampling for both lot tolerance and AOQL types of protection. These tables were first published in 1941 and in book form in 1944. Together with their earlier issues, these tables have been in use in the Bell System for over 25 years.

While at the Laboratories, Harry Romig was in charge of a group responsible for quality Assurance inspection specifications and was widely consulted on problems involving statistical methods. During World War II he was one of a group that was responsible for the development and preparation of the Army Ordnance and ASF Standard Sampling Tables, a forerunner of the MIL-STD-105A sampling tables of the Defense Department.

In 1948 he became vice chairman and in 1949 chairman of the Metropolitan Section of our Society.

In 1951 he left the Bell Telephone Laboratories to become quality control manager of Hughes Aircraft Company in Culver City, California. He is now quality director of International Telemeter Corporation of Los Angeles, and is the very active chairman of the fast-growing Los Angeles Section of our Society.

Aside from his many activities in our own Society, he has given generously of his time to other Societies. For example he was a member of one of the committees that was responsible for the *ASTM Manual on Quality Control of Materials*, both the current and the earlier editions, and has served on many quality control and inspection committees in the statistical, electronics and aircraft fields. He is the author of a recent book of binomial tables and has published a number of technical papers in the fields of credit and financial management, statistical methods, and quality control.

While his list of accomplishments is long, I think that one of his most outstanding contributions to our profession has been his continuing and active service to others, especially as an understanding guide and friend to many who have become interested in the field of quality control.

Mr. President, on behalf of the Shewhart Medal committee, I present to you and to this assembly the Shewhart Medalist for 1953, Dr. Harry Gutelius Romig.

The text of Dr. Romig's medalist address is presented on page 18.

The concluding portion of the banquet ceremonies consisted of the presentation to the group of the new 1954-55 officers. They are:

President: Raymond S. Saddoris

Vice Presidents:
Arthur Bender, Jr.
Paul A. Robert
Julian Toulouse

Adolphus Busch Orthwein, August A. Busch, Jr., Mrs. Walter Shewhart, Eberhard Anheuser, Walter Shewhart, and Donald F. Sager. Mr. Busch was host to ASQC conventioneers at the long-to-be-remembered pre-convention social at Grant Farms, home of Mrs. August A. Busch, Sr.

Executive Secretary:
Dorian Shainin

Treasurer: Leon Bass

In introducing the new president, Raymond Saddoris, retiring president Davis turned over the official gavel of ASQC. In addition he presented to Ray a special gavel and block which he had made up from a baseball bat used by Joe Adcock of the Milwaukee Braves. Incoming president Saddoris made a brief acceptance talk on behalf of the new officers and concluded with a presentation of several gifts to retiring president Davis on behalf of the outgoing officer group.

The final general gathering of the convention was at the Friday noon luncheon. Everyone was highly entertained by the luncheon speaker, Mr. G. A. Rohlfing of Aluminum Company of America. Mr. Rohlfing gave a humorous talk describing a mythical industrial enterprise, the Prefabricated Hole Company.

Although the convention officially closed after the technical sessions on Friday afternoon, the board of directors held its meeting late in the afternoon, and a good many people stayed over for the numerous Society committee meetings which were held on Saturday morning.

One of the highlights of the Eighth Annual Convention were the exhibits presented by various manufacturers. These companies were: American Cystoscope Makers, Inc.; American Instrument Co., Inc.; B. C. Ames Co.; Bausch & Lomb Optical Co.; Bendix Radio Division; Dolph O. Boettler Co.; Brown & Sharpe; Brush Electronics Co.; Bryant Chucking Grinder Co.; Century Electric Co.; Coca Cola Bottling Co.; Consolidated Vultee Aircraft Corp.; Continental Can Company, Inc.; A. G. Davis Gage & Engr. Co.; DoAll Company; Elliott Service Co.; Engis Equipment Co.; Federal Products Corp.; Ford Motor Co.; Friden Calculating Machine Co., Inc.; General Electric Co.; Greenfield Tap & Tool; The Greenleaf Manufacturing Co.; Industrial Scientific Co.; The Johnson Gage Co.; Jones & Lamson Machine Co.; Marchant Calculators, Inc.; McDonnell Aircraft Corp.; Merz Engineering Co.; Micrometrical Manufacturing Co.; Missouri School of Mines & Metallurgy; Monroe Calculating Machine Co., Inc.; Optical Gaging Products, Inc.; O-Vee Gauge Co.; Pratt & Whitney; Rimat Tool Co.; George Scherr Company; Service Diamond Tool Co.; Sheffield Corp.; The L. S. Starrett Company; Steel City Testing Machines; Taft-Peirce Manufacturing Co.; Tubular Micrometer Co.; Warner & Swasey Research Corp.; Washington University; Wilson Mechanical Instrument Division; The N. A. Woodworth Company.

Especially outstanding were the excellent facilities of the exposition hall. In addition to providing ample room for the above exhibits there was also the spacious book booth and ASQC booth. And most appreciated by the exhibit viewers were the courtesy booth operated by the Coca Cola Co., and the comfortable lounge area located at the center of the exhibit space.

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EDWARD CARTOTTO

North American Aviation, Inc.

Few techniques available to us are without short-comings or definite limitations. This we have recognized as we apply to our work the many theories available to us as operating tools. Invariably, as we apply these ideas, we seek to determine the extent to which we are justified in accepting the results of our analysis. Some purely mathematical devices yield completely unquestionable solutions. Others provide solutions acceptable within limits. It is with these latter devices that we are concerned. More specifically, we are concerned with a technique capable of evaluation on a probability basis.

Probability theory is not new. One early application of the theory dates back to the 17th century, when a French gambler asked two mathematicians to work out the odds in an unfinished card game. Little did they realize, at that time, that the seed they planted would some 300 years later break into full bloom in the desert of Nevada. Since then the laws of chance have been applied to problems of many fields. In the past 25 years they have dug deeply into problems of production and during the last decade many people have used these techniques in their work without realizing that they were, in a way, playing the part of a smart gambler.

The inspection technique to be described herein is known as the c-chart, popularized by exponents of statistical quality control. Its application makes possible watching the behavior of an instrumentation program that is complicated by varying requirements, and it provides a convenient base against which performance can be compared. Before describing the mechanics of the application, it might be wise to look into the reason for the application and into the basis for operation of this technique.

THE c-CHART AS A CONTROL TOOL

So far as the reason for applying the technique is concerned it can be said that any device that permits gaging the quality level of performance of a measurements program is desirable because it provides justification for action, which action can be directed toward effecting improvements in equipment, operating technique, and personnel training. Obviously, improvement in any one of these items is advantageous.

To understand the operation of the c-chart we must recognize that all operating systems, or processes, experience continuous variation and change. Some of these changes are caused by unpredictable events completely beyond control. They are definitely random in nature and are said to arise from non-assignable causes. Other variations stem from events over which control can be exercised. These variations are said to arise from assignable causes. A process operating under the influence of variations due only to non-assignable or chance causes is said to be in statistical control. Under this condition, process analysis by statistical inference is permissible.

Any of these variations is likely to cause the malfunction of a measuring circuit and thereby produce faulty data. If we keep a record of these malfunctions and then devise a way for determining whether the malfunction arose from assignable or non-assignable causes, we will have a means for watching the performance of our program. Just such a technique is available in the c-chart.

The operation of the c-chart is based on the Poisson frequency distribution which defines the relative frequencies with which possible numbers of occurrences of an event tend to appear. A typical Poisson distribution is shown in Fig. 1. This histogram was plotted from data resulting from 1000 observations (or

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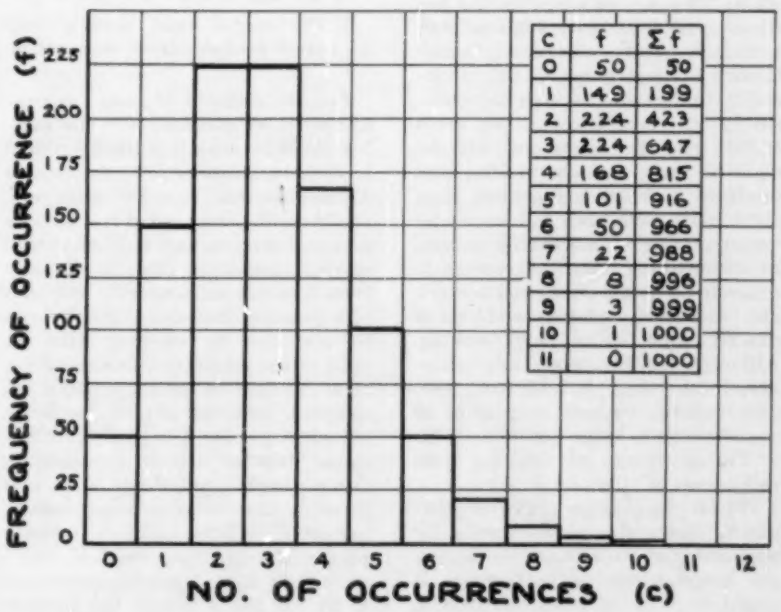

c	f	Σf
0	50	50
1	149	199
2	224	423
3	224	647
4	168	815
5	101	916
6	50	966
7	22	988
8	8	996
9	3	999
10	1	1000
11	0	1000

Figure 1—Poisson Distribution for Mean c' = 3

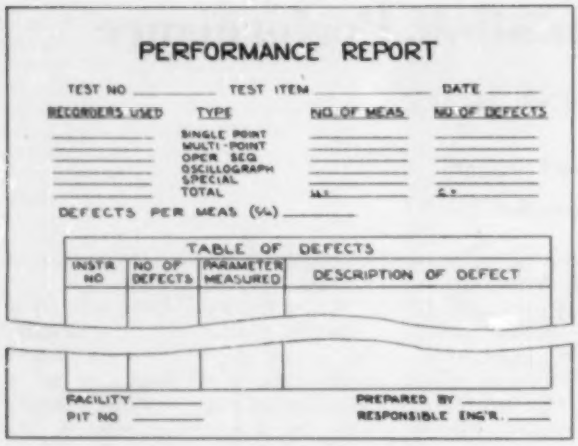

Figure 2—Performance Report

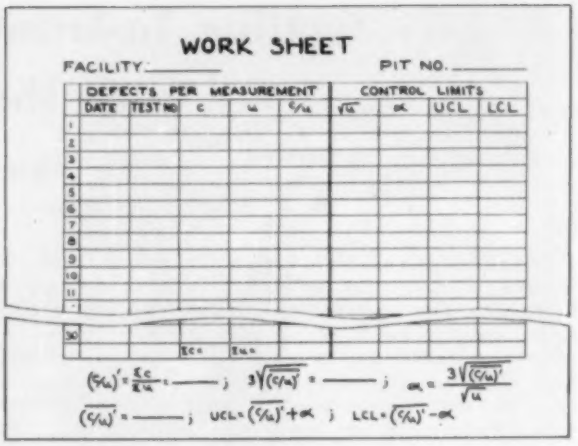

Figure 3—Work Sheet

tests) operating in such a way that the mean frequency of occurrence of an event is three, i.e. $c' = p'n = 3$. With such curves the frequency of occurrence is proportional to the probability of occurrence. Referring to the histogram, the probability is 0.101 that in a single set of observations the number of occurrences of an event will be exactly five. Considering these probabilities cumulatively we can say that the probability is 0.996 that in a single set of observations the number of occurrences of an event will be eight or less. This characteristic of the distribution gives us a means for setting an upper limit on our data at any probability level we choose. Practice has shown that a limit of 0.995 is both technically and economically satisfactory. The meaning of this probability limit is that because the probability of occurrences is so great (0.995 that the frequency will be eight or less), any observation that produces a frequency greater than eight must have been influenced by variation due to assignable causes. In other words, this limit serves to separate assignable from non-assignable causes of variation, and this is exactly what we've been seeking. Although this histogram was established from data derived from 1000 observations, we need only 20 or 30 observations to begin our study. This is the advantage of working with techniques of this sort.

If now the process under investigation meets the requirements for application of the c-chart, we can begin keeping records in earnest. It might be wise to point out that in most applications of the Poisson distribution it is possible to find flaws in the theoretical applicability but as long as these flaws are of minor nature, the results obtained are quite likely to be good enough for practical purposes. The requirements for application can be stated as follows:

1. The process must be capable of analysis by attributes.
2. Events under investigation must be mutually independent.
3. Units of inspection must present equal areas of opportunity.
4. The events under investigation must have an infinite number of opportunities to occur; and
5. The events must have a very small probability of occurrence.

The requirement of Item 1 is easily met if we merely count the malfunctions or defects without regard to their seriousness or to the degree of defectiveness. Item 2 is quite generally met except where a serious personal error causes malfunction of several measuring circuits. Usually Item 3 is not satisfactorily met in a test program but this difficulty can be overcome by working with the ratio of the number of defects to the total number of measurements attempted. In a test of even moderate complexity, Item 4 is easily met because "infinite" can be replaced by "very large," and Item 5 is met through the energies expended by personnel in attempting to make a perfect set-up. The extent to which we satisfy Item 4 can be recognized if we list but a few of the possible sources of trouble in recording a variable like chamber pressure. Some events that might occur and thereby produce faulty data are:

1. Pressure pickup over-ranging
2. Recorder pen failure
3. Chart motor failure
4. Insulation failure
5. Electrical connector failure
6. Pneumatic circuit failure
7. Power failure
8. Recorder amplifier failure
9. Switch failure
10. Temperature influence on pickup

These are ten general ways in which failures might occur. Many of these contain hidden sources of trouble that increase the total number of sources to a large figure. For example, in how many ways might an amplifier fail? Also, in how many ways might the chart motor fail?

APPLYING THE c-CHART

There is little doubt that our process meets the five requirements well enough to warrant using the c-chart. Now the question is, "How do we apply it?" First we must define a defect. The detailed definition becomes somewhat complicated because we must count defects in whole numbers. We cannot account for half a defect. The defect either exists or it does not. In a general way we can define a defect as any event that contributes to the production of faulty data. This will include any defect that develops during the

test or any defect uncovered after having acknowledged the measuring system's readiness for service.

For the purpose of gathering data and making the calculation, two types of data sheets have been found useful. These are shown in Figs. 2 and 3. A Performance Report is prepared for every test conducted. Each test is considered a unit of inspection and the Performance Report provides a detailed record of each defect and of the total number and kind of recordings made. The Work Sheet is a summary sheet from which we calculate the mean and limits. Notice that at the bottom of the Work Sheet there are formulas for computing the average and the limits. In these, c equals the number of defects that occurred in a test and u the total number of measurements attempted in the test. The ratio c/u is, of course, the number of defects per measurement. $(c/u)'$ is the mean for 30 tests and $\overline{(c/u)}'$ is the grand average of all values of $(c/u)'$.

Notice that the control limits, identified as UCL and LCL (upper control limit and lower control limit) are calculated from a relatively simple formula. These limits are based upon the measure of dispersion known as the standard deviation (σ) and while they are not exactly equal to the probability limits, they are quite satisfactory for small values of $(c/u)'$. Using the control limits based on σ affords the advantage of being able to work without reference to probability charts or tables.

A typical chart of defects per measurement is shown in the Fig. 4. Each such chart contains records from but a single test pit. It includes data from 90 tests, divided into three groups of 30 for easy utilization of the Work Sheet. In addition to individual values c/u and the control limit, the chart shows $(c/u)'$, the mean number of defects per measurement, and $\overline{(c/u)}'$, the grand average. The mean identifies the performance during only one 30-test group; the grand average for all 90 tests. Carrying both records simultaneously provides a way for comparing current performance with total performance.

The chart shows points outside of control limits. This indicates that variations due to assignable causes influenced the process and dictates that action should and can be taken to prevent recurrence of the defect. Note that LCL does not appear on the chart. Only when LCL has a positive value is it plotted because an LCL less than zero cannot exist.

Keeping records and charts of this sort is time consuming, but our experience is that they are worthwhile. In addition to presenting a running account of performance, they keep the instrumentation engineer aware of what happens to instrumentation performance when his efforts are relaxed, and they stimulate a little friendly competition between crews of different pits. Both of these factors go a long way toward keeping alive the spirit necessary to do a good job.

Recently, changes have been made in our definition of defects and although this has changed the numbers associated with our charts, their use remains unchanged. Another modification is being studied and that is the possibility of weighting the defects so that a defect in a critical measurement will have a greater influence on the chart than a noncritical measurement. Such a change will alter considerably our routine in recording data and making calculations, but the finished charts will still be subject to the same general interpretation.

One difficulty not to be overlooked in using the c-chart is that of keeping the chart honest. Persons who count defects are frequently tempted to examine the charts in their favor and record fewer defects than actually exist. For example, a pen may have left several un-inked portions in a record. Under this condition it might be argued that because we know what to expect of the variable being recorded, this small flaw need not be counted as a defect just because there are a few breaks in trace. Although this is sometimes done, it is not correct. The records should show a defect produced by pen malfunction.

Like most other inspection techniques, this one requires some selling, especially to the mechanic. He must be convinced that the purpose of the chart is not to put the blame for failure on him. Until he is convinced, he is very likely to bias the records by too liberal an attitude and by taking more credit than is due him.

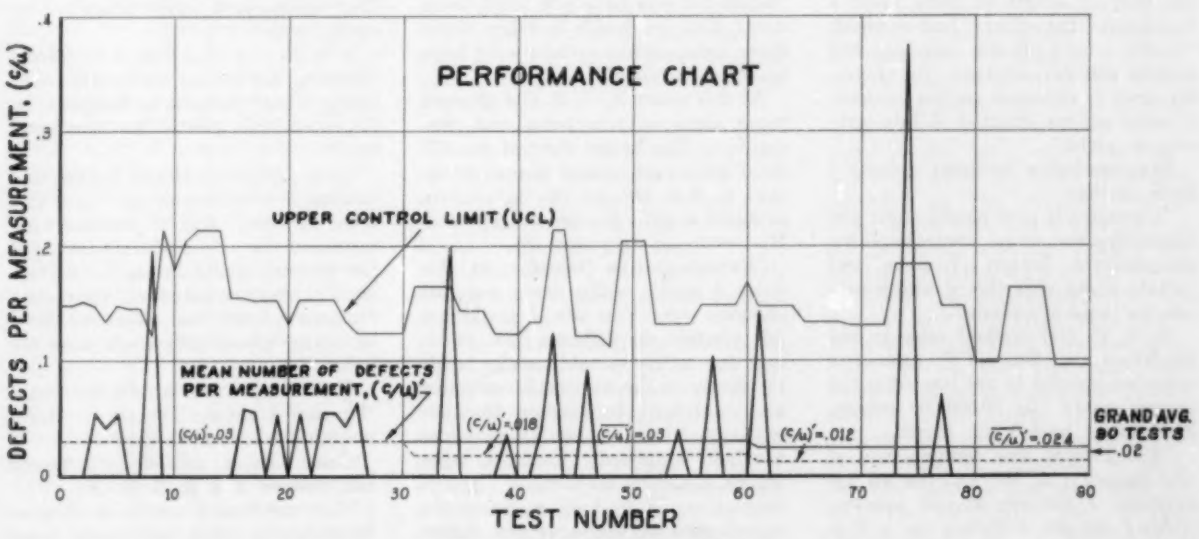

Figure 4—Performance Chart

Investigation of Latin Squares

FRANK PROSCHAN

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Congressional committees have been investigating a wide variety of subjects, including crime, communism, taxation, etc. Will statistical methods be next?

This modern parable, though far-fetched and fantastic, explains the useful experimental design, the Latin square.

"Would you take the stand please. State your full name and occupation."

"Xavier Steven Francis Ort, chemist at the Atomic Energy Laboratory."

"Now, Mr. X. S. F. Ort, would you tell us to the best of your recollection what you did in your lab during the week of June 9-16, 1952."

"Yes, Representative Samples. We were interested in finding the best method for extracting uranium from pitchblende ore by acid digestion. As the first step, I was going to determine whether temperature of digestion, length of time of digestion, and sulfate content of the ore influenced the percentage of uranium recovered. I also wanted to determine what range of each variable had the greatest effect on yield, so that I could concentrate my efforts accordingly to get an optimum solution."

"How did you plan to find the effect of these three variables on yield?"

"Naturally, I studied the effect of each variable separately. I held all the variables but temperature constant. I let temperature vary and found out what effect temperature had on yield. Then I held all the variables but length of time constant. By varying length of time only, I found out what effect it had on yield. Finally I held all the variables but sulfate content constant. By choosing ores of different sulfate content, I found out the effect of sulfate content on yield."

Representative Samples delved a little further.

"I wonder if you would show the committee the actual values used for temperature, length of time, and sulfate along with the resulting values for yield of uranium."

X. S. F. Ort walked over to the blackboard. The TV cameras wheeled around to get him onto the screen again. In 20,000,000 homes, Americans held their breath.

"Sir, I fixed the temperature of the digestion at 40° and the sulfate content of the ore at two percent. Then I ran the digestion for 1, 2, 4, and 8 hours. Similarly, I fixed the time at one hour and the sulfate concentration at two percent. Then I used temperatures of 40°, 60°, 80°, and 100°. Finally, I fixed the time at one hour and the temperature at 40°. Then I used sulfate concentrations of 2, 7, 12, and 17 percent. Here are the results I got:

Set 1

For Sulfate Content 2%, Temperature 40°C

Time (Hours)	1	2	4	8
U Yield (%)	42	47	41	44

Set 2

For Time 1 hour, Sulfate Content 2%

Temperature (°C)	40	60	80	100
U Yield (%)	42	46	44	45

Set 3

For Time 1 hour, Temperature 40°C

Sulfate Content (%)	2	7	12	17
U Yield (%)	42	41	42	32

Representative Samples queried: "What did you conclude from these data? Did you decide that any of the three independent variables did have an effect on yield?"

At this point X. S. F. Ort showed some signs of weariness and discomfort. The bright light of the TV floodlamps had caused the perspiration to flow freely. His voice, too, sounded slightly hoarse and strained. He continued however:

"Representative Samples, at this point I could really draw no conclusions yet. You see, I could not tell whether the differences in yields was due to the variable under study or simply to the inevitable sampling and analytical fluctuations that are experienced even when all variables are held supposedly fixed. In other words, I had no estimate of 'experimental error' to help evaluate the significance of the observed differences in yields."

Representative Samples frowned. "But your data thus far permit no estimate of experimental error."

"Yes, sir, I didn't stop at that point, though. I did some further experiments to determine the magnitude of experimental error. I simply reran the first two trials of each of the three sets listed. Here are the rerun values along with the results I listed before"

For Sulfate Content 2%, Temperature 40°C

Time (Hours)		1	2
Original	U Yield (%)	42	47
Rerun	U Yield (%)	43	45

For Time 1 Hour, Sulfate Content 2%

Temperature (°C)		40	60
Original	U Yield (%)	42	46
Rerun	U Yield (%)	43	44

For Time 1 Hour, Temperature 40°C

Sulfate Content (%)		2	7
Original	U Yield	42	41
Rerun	U Yield	41	42

At this point, the chairman of the committee, vitriolic Cong. Oleum, feared far and wide for his acid tongue, spoke with asperity.

"Mr. Ort, you stated that you determined the effect of time on yield for the combination sulfate content two percent and temperature 40°C. Now, *why* did you choose that particular combination of values of sulfate content and temperature? Any special reason?"

X. S. F. Ort squirmed in his chair. "Mmmm, not really," he said hesitatingly, "I had to start somewhere, so I picked that particular combination."

Cong. Oleum continued his embarrassing line of reasoning. "Is it not true, however, that if you had determined the effect of time on yield for *several* combinations of sulfate content and temperature, your conclusions about the effect of time would have been that much more reliable?"

Ort's brow was coated with sweat. "No sir—I mean, yes sir. I think your point is well taken."

Cong. Oleum picked up a pencil and pointed it at X. S. F. Ort.

"Let me make my point clearer. Realistically, what we would want to determine from this experiment is

not the effect of time on yield for a *particular* combination of sulfate content and temperature, but the separate effect of time on yield independent of the variations of sulfate content and temperature; similarly, for each of the other two variables."

X. S. F. Ort mopped his brow. "Yes, that *is* true. I can see that my experimental design was lacking in that respect."

Cong. Oleum took a step closer to hapless Ort. A thrill of tense excitement was felt in 20,000,000 homes; the atmosphere was that of a Spanish bullfighter at the supreme moment when the matador steps forward to kill the doomed bull. Oleum spoke softly at first; at the finish his voice boomed.

"Mr. Ort, my job is to see that the American people get maximum return for each dollar of tax money spent. Now, remembering that you're under oath, would you say that your experiment design was the most efficient possible?

X. S. F. Ort, turned deathly pale. He suddenly discovered that his hoarse throat had matured into a case of laryngitis.

"Sir," he croaked, "may I return after rest and treatment? My throat is killing me."

All over America, eager TV viewers sneered.

The committee conferred hastily and then agreed to permit the witness to return the following day. X. S. F. Ort breathed a sigh of relief and left the stand.

The next witness called to the stand aroused a great deal of interest throughout the hearing room, in fact, all over America. Minnie Mum F. Ort, wife of X. S. F. Ort, was a beautiful, stately blonde, clearly possessed of great poise and intelligence. In questioning Minnie, Cong. Oleum adopted a much more amicable and winning manner.

"Mrs. Ort, you are the wife and co-worker of the last witness X. S. F. Ort, are you not?"

Minnie Mum F. Ort's voice shook just a little as she replied, "Yes, Congressman; however, we separated as a result of a difference of opinion on the proper way to run the uranium yield experiment."

"Mrs. Ort, on what grounds did you disagree with your husband on this experiment?"

"Sir, I felt that this experiment could have been designed to yield much more information at the same cost. We could have got much more for the government's money if we had used a Latin square design."

At the mention of "Latin square," Rep. Resent leaped. As chairman of a House Committee on Subversive Activities, he was vitally interested in Minnie's revelation.

Pronouncing each word with great deliberateness, Rep. Resent asked, "Are you now, or have you ever been, a member of the American Statistical Association?"

All movement, all noise ceased in the crowded committee room. So much depended on Minnie's answer! A contempt citation, perjury charges —these might be consequences of her next words.

Looking Rep. Resent straight in the eye, Minnie defiantly replied, "I refuse to answer on the ground that it might incriminate me."

Rep. Resent turned purple with fury. However, Cong. Oleum did not permit the hearing to be sidetracked from its main purpose.

"Mrs. Ort, returning to our original line of questioning, would you explain what a Latin square is?"

"I think I can best explain in terms of our actual problem. A Latin square design for this experiment would be arranged like this:

TABLE 1

Temp.	Length of Time *Hours* 1	2	4	8
40	2	7	12	17
60	12	17	2	7
80	17	12	7	2
100	7	2	17	12

"The entry in the body of the table gives the sulfate content (in percent) of the ore digested for the length of time given by the column heading and at the temperature specified by the row heading."

Representative Samples commented, "That's an interesting setup. I notice that each of the four sulfate values occurs once and only once in each row and in each column. Is that deliberately arranged?"

Minnie Mum F. Ort smiled with pleasure at the Congressman's quick insight.

"Yes, exactly. That has the following consequence: Suppose we are interested in the effect of time on U yield. Since each sulfate content value occurs the same number of times (once exactly) for each time of digestion (1, 2, 4, and 8 hours), our comparison of the yields for the different lengths of time is uninfluenced by the effects of sulfate content. In other words, the effects of sulfate content on U yield are cancelled out, since they influence each column equally.

The audience in the committee room burst into spontaneous applause. Cong. Oleum contributed:

"It's also true, isn't it, that in comparing the U yields for the four different lengths of time, the effect of *temperature* has been removed. This would follow from the fact that each of the four temperatures occurs exactly once in each column."

Representative Samples questioned further, "You say that you separated from your husband because you felt that the Latin square experimental design was superior to the so-called "classical" design proposed by your husband. Now I don't want to delve into your marital life, but could you explain why you think the Latin square is preferable?"

Minnie Mum F. Ort smiled bravely. "In the first place, in the Latin square design that I set up, when we compare, say the 40°C yield with the 60°C yield, we are comparing averages of four values, whereas in the classical design, in comparing the 40° yield with the 60° yield, we are comparing averages of only *two* values. Clearly, under the Latin square design, you get double the precision compared to the classical design. In fact, some of the comparisons in the classical design were based on only *one* value, as compared with the four used in every case in the Latin square design, so that the precision is four times as great for the Latin square in these cases."

Representative Samples commented, "In other words, in this experiment the precision of the Latin square is anywhere from two to four times as great as that of the classical design. Are there any other advantages to the Latin square design?"

Minnie Mum F. Ort's blue eyes sparkled as she eagerly replied, "Yes, there are: Let's first look at my husband's classical design. He started by fixing the temperature at 40°C and the sulfate content at two percent, and then found how length of time affected yield. Suppose, however, that for that particular combination of temperature and sulfate content the influence of length of time on yield is not typical of what it is for other combinations of temperature and sulfate content. We will have been misled by an unfortunate choice of temperature and sulfate as to the effect of length of

time on yield. The same sort of false conclusicn may be reached regarding any of the other variables."

Cong. Oleum exclaimed indignantly, "No wonder you separated from X. S. F. Ort! Why he was exercising the most heinous sort of mental cruelty by insisting on the classical design! But tell me, would the Latin square have avoided the sort of error you've just described?"

Without hesitation, Minnie Mum F. Ort exclaimed, "Yes! You see, in the Latin square design if, for example, we are studying the effect of time on yield we would compare the averages of the four columns (Table 1). Notice that each column average is equally influenced by the four different temperatures and also equally influenced by the four sulfate contents. Hence, in studying the effect of time on yield we are using not just one arbitrary combination of the other two independent variables but, in a sense, the 'average' combination of the other two variables."

Representative Samples summed up, "Would you say then that the Latin square has two advantages over the classical design:

1. It gives far greater precision.

2. It studies the effect of a variable not at some arbitrary combination of the other two variables, but for the 'average' combination of the other two variables."

"Yes, Representative Samples, exactly."

The committee then thanked Minnie Mum F. Ort and called the next witness, Wright D. Duckshun, to the stand.

The portly, florid government consultant faced the TV cameras. He spoke first.

"Sir, may I ask a favor of the esteemed committee? Even though I shun publicity, I have volunteered to testify before the committee. In return, I would like to ask that the TV cameras not be focused on my face."

As a compromise, the TV cameras were focused on the witness' hands. Wright D. Duckshun's hands modestly folded.

Cong. Oleum asked, "Sir, I understand you're an industrial consultant specialising in Latin squares. Could you tell us some more about them?"

Wright D. Duckshun's fingers showed poise and assurance. "Sir, I would like to add some sober cautions to Mrs. Ort's description of the Latin square. For one thing, if two of the factors interact—say, if temperature and length of time interact, then the observed experimental error will be inflated."

Representative Samples: "What do you mean by interact?"

Duckshun: "Suppose the combined effect of temperature and length of time is not simply the sum of the effect of temperature alone and the effect of length of time alone. In other words, the effect of the two factors *together* is not simply additive. In that cast, the two factors are said to interact."

Cong. Oleum: "Could you illustrate?"

Duckshun: "Suppose, to pick a very simple situation, a change in temperature from 80° to 90° resulted in an increase in yield of five percent. Suppose, too, a change in length of time from two hours to four hours resulted in an increase in yield of seven percent. That would mean that if the two factors combined in a simple additive fashion, a change in temperature from 80° to 90° and a change in length of time from two hours to four hours should result in an increase of yield of—." Here Wright D. Duckshun added rapidly cn the fingers of both hands, "—12 percent."

A startled murmur spread through the hearing room and was echoed in every TV home throughout the land. Wright D. Duckshun quickly folded his unusual hands in embarrassment, and continued somewhat shaken. "But suppose it turned out the increase in yield was actually only six percent because of the fact that at the higher temperature additional time had little effect. In such a case, *interaction* of temperature and time would be present."

Representative Samples asked, "In such a case, you said before that the observed experimental error would be inflated. What would that imply?"

"It would mean that the effect of, say, sulfate content might not be detected because of the large observed experimental error with which the variability due to sulfate content must be compared."

Representative Samples: "In other words, the Latin square is not an appropriate design where interaction between two of the factors is appreciable. In what sort of problem *would* it be applicable?"

Duckshun: "It would be applicable to these types of problems:

1. The type X. S. F. Ort described—where you would be interested in determining in an approximate way whether each of three independent variables affected the dependent variable or not and roughly what ranges of the independent variables were most worthwhile studying. In other words, it would be a good introductory experiment requiring far fewer trials than would be required if all combinations of the three variables were used.

2. "It would also be useful in case some of the combinations of the three variables were impractical or impossible to obtain.

3. "Finally, the Latin square design may be used when there are only two independent variables under study, but an additional unavoidable source of variation is present. For example, look at Table 1 again. Suppose sulfate content was not a factor in this experiment. Suppose instead, there were 4 different batches of ore to be used for the experiment. The arrangement of temperature and time treatments would be as before, with each of the four numbers (2, 7, 12, 17) replaced by a batch number. Similarly, the Latin square design may be useful when there is *one* variable and *two* unavoidable sources of variation."

At this point, Representative Samples stood up, thanked Wright D. Duckshun for his valuable testimony, and shook hands with him somewhat gingerly. He then announced that the Committee would recess for one month during which time it would prepare its summary report recommending appropriate legislative action.

* * * * *

One month later, the chairman of the Committee, Cong. Oleum, facing the TV cameras began his speech reporting the principal findings of the Committee.

"My friends, the Committee has fearlessly pursued—". A sudden commotion drowned out his next words. An excited X. S. F. Ort rushed forward.

"Sir", he shouted, "may I make one statement before you continue?"

Cong. Oleum at first glared balefully at the emotional figure before him. Then his curiosity triumphed over his anger. "What *is* it?" he asked with irritation.

"Cong. Oleum, I want to report to the Committee that I have seen the

error of my ways, and have renounced inefficient methods of experimentation. I have decided to devote my life to modern statistical methods of experimental design."

Cong. Oleum's irritation vanished. He smiled at X. S. F. Ort's excitement. X. S. F. Ort continued:

"Sir, I must tell you the other good news. Minnie Mum and I have reached a reconciliation!"

Cong. Oleum beamed. "Wonderful," he exclaimed. Then his face resumed its serious mien. "Here are the principal findings of the Committee." Cong. Oleum then presented the following report:

Report of the Congressional Committee on Proper Design of Experiments

In conducting an experiment to determine the effect that three factors have on some dependent variable, a Latin square design is often very efficient. If the three factors, A, B, C, occur at, say, four levels each, 1, 2, 3, 4 the Latin square design may be represented as

	A_1	A_2	A_3	A_4
B_1	C_1	C_2	C_3	C_4
B_2	C_4	C_1	C_2	C_3
B_3	C_3	C_4	C_1	C_2
B_4	C_2	C_3	C_4	C_1

This means that the dependent variable is measured at combination A_1, B_1, C_1, at combination A_1,B_2,C_4, etc.

The "classical" way of conducting an experiment to determine the effects of the three factors is to hold all factors (at some arbitrary level, usually) but one constant and let that one factor vary. Then all factors but the second are held constant, while the second factor is allowed to vary, etc. In this way, a series of separate experiments are conducted each on the effect of one factor at a time.

It has been shown by modern statistical analysis, that the Latin square design yields more information than the classical method for the same expenditure of effort because.

1. It gives greater precision.

2. It studies the effect of a factor not at some arbitrary combination of the other two factors, but for the "average" combination of the other two factors.

However, if interaction between two of the factors is present, the experimental error becomes inflated, and the effect of the third factor may not be detected. Nevertheless, as a first step in determining the effects of several factors and ranges in which these factors are most influential, the Latin square is quite valuable.

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4. L. H. C. Tippett, *Technological Application of Statistics*, John Wiley and Sons, Inc., 1950.
5. W. J. Youden, *Statistical Methods for Chemists*, John Wiley and Sons, Inc., 1951. Pages 90-99 contain several worked examples of Latin squares.

Quality Control by Infiltration

H. J. JACOBSON

Grand Sheet Metal Products Co., Melrose Park, Ill.

By far the greatest problem encountered by the quality control engineer when he sets up his new department, is how to accomplish the most effective results in the shortest possible time. In other words, he has a job to do to sell quality control not only to management, if he wants to hold his job, but most important, to the foreman and the worker, if he is to show results.

To start with, let's remember that we are dealing with individuals whose personalities and temperaments vary. These are people who do not concern themselves with quality except as it directly affects their earnings. Their feeling is that if a company is concerned with quality, then the company has to find a means of maintaining it. The operator is no longer a skilled artisan. His pay check is in direct proportion to the number of pieces he produces, and his job security is dependent primarily on his being on the same production level as his fellow workers.

Perhaps the first real contribution quality control has made has been in proving to the workman that, when processes are controlled, he can make product with the assurance that whatever was done before is good. This assurance makes the workman feel that he must produce quality workmanship if he is to be on a par with his fellow workers. He has the assurance too that he has more chance of meeting his quota when he does not have to stop to throw out a bad part.

Let's see now what modern quality control can do for an industry. We harp continually in all our lectures and papers on quality control about educating the worker. The plan is always to indoctrinate quality mindedness into the employee. We start generally with the upper levels of supervision, showing them what our methods can do and proving, by simple experiments, the logic behind our statistical theory. These people are not too hard to convince. They are in general open-minded, intelligent men who have reached their position in the company because of these traits.

Next we tackle the more difficult job of indoctrinating our line supervisors. Many of these are men of long service, and unfortunately little education. They have come up the hard way and have little sympathy for new fangled ideas. They have seen the efficiency experts come and go, and they have had their innings with the time study engineers. They are a hard-headed bunch, but they too can be convinced, if only be-

cause they are essentially management people, on management's team.

Now we are ready to tackle the most difficult problem of all. Convince the worker. Make the material handler, the floor sweeper, the man on the bench, see the light. We rack our brains for ideas to try to bring a message to him. We pat him on the back, we compliment him, or we bawl him out, and sometimes fire him. We try to give him incentives for good work, sometimes fear for bad work, and each and every artifice we use does something. It takes a long time to install quality mindedness in an employee, especially one with long service in the company.

Do you wonder why it is so hard to convince him? Well let's take a look at the past. We have progressed from the small owner-operated shop of a few people to the employment of a city of people to make a single product. We have by-passed the skill of the individual in favor of a high production mechanization. Before, a man's work was measured by its quality, and its price was a reflection of his workmanship. Now, production is the factor in lower cost and perfection is secondary. Management became too concerned with the maximum work load of an employee without regard for previous conditions that may have caused an operator trouble, and over which he had no control. The individual became a machine, able to do an average amount of work in a given length of time with the proper mechanical assistance. Only when you can show the operator that as processes are controlled, he gets better product to work with, with the assurance of higher production and greater earnings, will your real quality problems be solved.

How about our methods? How effective are they? Let's approach the problem from a purely psychological stand. Everything we hear makes some impression on our subconscious mind. Our approach must be one of invitation to learning. The persuasive yet gentle reminder of today's so-successful advertising. The placement of a poster, unobtrusively. The customer thank-you letter on the bulletin board. The effort the quality control department extends in making friends. All these are leading the horse to the water. When he becomes thirsty, he too will drink.

Many ways are successful. Some more than others, and each is dependent on the time and place, and the attitude of the people. Posters, of course. These should be carefully selected as to reading matter and cartooning to prevent possible lampooning of company or individual. Placed where they can be readily seen, and if possible in conjunction with a daily or weekly news item. Something of current interest to most people will focus their attention to a poster that is next to it.

Make a defect board. Hang a board on a wall somewhere in a prominent location with a few hooks on it and hang up some of your obvious defects. Make it neat, letter it nicely. Say something like "Boy! Who made this?" or "Let's Produce Quality Not Scrap." Change your defectives weekly. Don't pick out any one department for criticism. You can even put a table or display in the middle of the floor piled high with scrap or reject parts. A large sign could give the total cost of the scrap. No blame to anyone. Just the inference that scrap is costly.

Control charts? Sure! Post them prominently. Keep them clean and up to date. Make them as big as you can get away with. Mount them on a brightly colored background. Use any means you can to indicate out-of-control product. Red lights, a bell, a signal arm, a cartoon. Show the green light too when product is good. Give the department or the operators something to brag about. Keep your chart simple and easy to understand. Too often the average intelligence level is about fifth grade.

Plant cleanup—that's your baby too. Do your best to keep the plant clean. Work up a cleanup program, rating each department daily on neatness. Post cleanup charts on a demerit basis. Give a banner or a plaque to the cleanest department. Keep your aisle lines painted. See that material is placed within the aisle, and is properly stacked. Make trash barrels and paint them white. Employees like a clean place. They will learn to cooperate and like it. You will find your quality improving too. The cleaner you get, the more careful the employee.

Movies during lunch time or coffee break periods. Try it. The cost of a projector is cheap compared to its educational value. Most films are free or available at a minor cost. Show movies on baseball, fishing, dress styles, and every once in a while a film on safety, cleanliness, or some such thing. Stress safety, that's part of your job too. A safe plant has good morale, and good morale tends to quality workmanship. Cut down your accident rate and you have shown your boss some real results.

Do your quality control inspectors have regular stations? Mark them clearly. Make a sign to show that *this is it!* Keep the area so clean you can eat off the floor. Then brag about it!

Do you have floor or patrol inspection? Buy your inspector a white coat. Put the letters "Quality Control" on his back. In red! Make them large. Let everyone see it. Keep his coat clean through a laundry service. After the first few months of calling him a butcher things will settle down and you have made some talk and consequently some progress. Not only that, but the operator and the foreman see him more easily. They are aware of his presence and consequently aware of quality.

Reports? Here is where you shine. Report everything. Let the department supervisor know your people are around. For awhile you'll be a stool pigeon, and a know-all, see-all. You will be the guy that tells everyone that something is wrong, but never do anything about it. You've got the soft job. All you have to do is say the part is no good and report it. "And this too shall pass," for time is a great leveler, and people get used to things quite easily. After a while the foreman will begin to realize that you're there to help him, not hinder him. When he begins to take action on your reports, you know you have won the first round.

Make yourself popular with the gang. Bowl with them, play baseball, invite them to the house for cocktails. Don't be ingratiating but talk quality control. Make jokes about it, but keep talking. Every-time you use the words "quality control" you have done some advertising. Don't take a back seat. Show people illustrations of quality control in other fields. Open a magazine, and count the number of ads that have the word quality in them. If you want quality, you have to talk quality.

Don't be a stool pigeon. What you hear don't repeat. Make use of your information, but don't tell where it comes from, unless it is complimentary to the person who told you.

People will learn they can trust you, and when they do you have made another big step.

Everything must be sold. Whether it's an idea or an actual product you must convince the man who has to buy. Since no two people react the same way to an approach, there must be many methods. Don't stick your nose up at modern advertising methods. The advertisement that get's the most success is the one that appeals to the better judgment of the buyer. How many of you have listened to the Lucky Strike program and have then calmly proceeded to tear a cigarette down the middle? The cost of those torn cigarettes alone might even pay for the advertising. But here there is an appeal to your intelligence. Whether or not the story you have been told is factual, half your mind is made up to believe in the results.

True or false, quality control can accomplish the same objective. If the radio tells you day in and day out to buy "X" product and you eventually buy it, then good advertising can also get you better quality. There are no special levels of understanding at which this advertising may be aimed. It must encompass the intelligence of a four-year old to that of a college graduate. No one method can be seriously considered as better than another. Rather, the more types of approach you use, like the scatter of a shot gun, the more people you can convince.

I do not hold with the belief that statistics will speak for themselves. I do not believe that just because a control chart has shown up an improvement there has necessarily been an advance in the stature of the quality control department. Not unless they have made the most of a good job well done, and have ballyhooed their results all over the plant, as well as brag that they could do as well in other situations. People must be convinced in all of their senses, not alone that of sight. If you don't believe that, try the beer test. Take a bottle of beer from the freezer and let it warm for five minutes. Pour a glass from that bottle and a glass from one right out of the freezer. Hand both glasses to a man who claims he knows beer. Tell him they are two different beers and you want him to tell you which is best. At the same time talk about one glass. The foam is higher, its got more life, the color is pale, slightly lighter than the other. Hold them to the light, one has more fizz. You can definitely convince him that not only are they different beers, but the taste is also different.

You are not a director of quality control for nothing. Your boss didn't hire you to sit at a desk and draw charts all day. He wants quality in his plant at the lowest cost, and he expects you to get it for him. He doesn't ask you, "How do you do it?" He just want's results. It's up to you to play the game with everything you've got on the ball. When you have built quality minded employees you have a successful quality control program. From there on, your charts will work like magic; you can really begin to build quality into your product. You will begin to reap the results of a successful psychological approach.

The Consumer-Vendor Relationship — A Mutual Responsibility

J. PHILIP WORTH

Electrolux Corporation

Since the beginning of the Korean conflict, modern industrial plans for the expansion of domestic lines have been exploded. A new concept for industrial activity has arisen which is phrased the "guns and butter" program, and in spite of the cessation of hostilities, it is still in effect.

In this program untested theories for the proper allocation of limited basic materials have been put into effect. Material allocations have affected both military and domestic consumption. As a result consumers and vendors are faced with the confusion of unpredictable material deliveries. Such confusion can so impede the natural flow of goods as to lead to material substitutions, relaxed standards, lowered inspector morale, and even an independent attitude on the part of some purchasing agents and vendors.

From my observation, there are many people who are vitally interested in the far reaching effects of this program. Those who have outstanding interest are:

1. The purchasing agent who has to buy a conforming product at the right price, in the proper quantity, and on schedule.

2. The vendor who has to deliver as the purchasing agent requests.

3. The quality control manager who must deliver only uniform conforming products to the production departments.

Of these, the quality control manager, although listed in third place, is the most affected. This is because he is in the middle of a conflict. When he rejects material he is plagued with complaints from management, who sometimes use higher authority to accept the rejected lot. When materials are accepted which do not adequately conform, the complaints originate from the production departments. In addition, sometimes the vendor's allocations for rejected material are restricted and it cannot be replaced.

When such conditions arise, the quality control manager can put into action the executive skill for which he has been trained. He is also ideally situated where he can improve his own position and be an important link between consumer and vendor. This should be

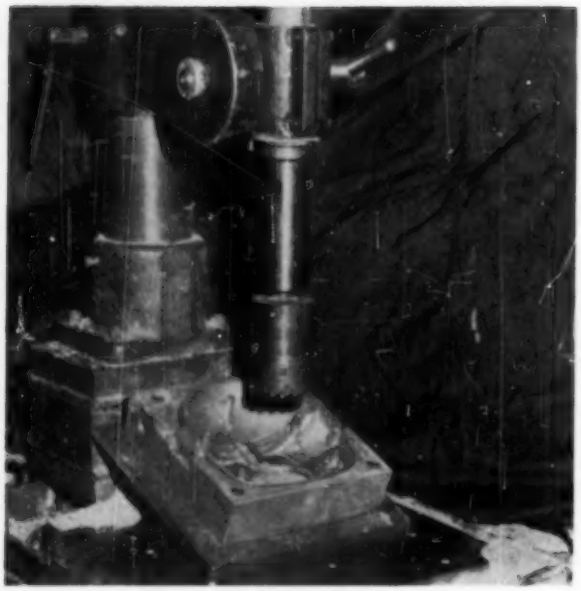

Figure 1—Cover in Nest

done by a carefully planned program of consumer-vendor liaison for the promotion of mutual progress and responsibility.

There are several companies who now have established plans for quality liaison between consumer and vendor. The merits of these will not be discussed here, because the purpose at this time is to reopen the consumer-vendor relations subject for the whole society. With this in mind I therefore propose to discuss:

THE QC MANAGER AS THE KEY FIGURE

To briefly state this condition, the quality control manager:

a. Knows the specifications of the material.

b. Has provided the inspection plan and testing equipment.

c. Is familiar with the fabricating operations and end use of the material.

d. Receives first-hand, detailed information on all materials received.

e. Can review inspection data with the purchasing agent.

f. Will request detailed information of vendor processes from the purchasing agent or vendor representatives.

g. Can receive permission to inspect vendor facilities to aid in solving mutual quality problems.

h. Provide liaison between consumer and vendor for quality control purposes.

i. Establish an effective control at the vendor's plant.

j. Can reduce consumer's inspection expenses as vendor's quality improves.

DEVELOPMENT OF MUTUAL RESPONSIBILITY

Shortly after V-J day, Electrolux realized that the 1940 manufacturing plan would not produce the maximum quality and quantity required by its sales department, except at a substantial increase in unit cost. One of the outstanding examples was the routine of receiving inspection, machining, finishing, and assembling of die castings purchased from B company.

Prior to World War II, parts were cast by B company and used by Electrolux on a relaxed production schedule and at lower labor rates. Conditions of that type provided a relaxed atmosphere when handling quality fluctuations. When contact was required, it was considered a function of a purchasing department employee or his delegate. Contact was conducted through B company's sales department, by phone or letter, and in due time the adjustments were made. With the expanded production, faster action was required on quality variances.

First Step—Quality Department Enters Consumer-Vendor Relationship

The quality department being familiar with the type, variety, and magnitude of variance, was requested to take action for faster permanent correction. The entry of quality personnel was made through B company's sales department with permission to work directly with manufacturing personnel from the plant manager down.

Second Step—Consumer-Vendor Quality Agreement

During the first meeting at the B company plant, the conditions of quality variance were discussed in detail to show why corrections were required. In addition, Electrolux outlined a plan for liaison by installation of our inspector who would be in first-hand contact with all phases of the quality function in both plants. These were accepted as fact, but without too much enthusiasm because of past history and a normal resistance to change.

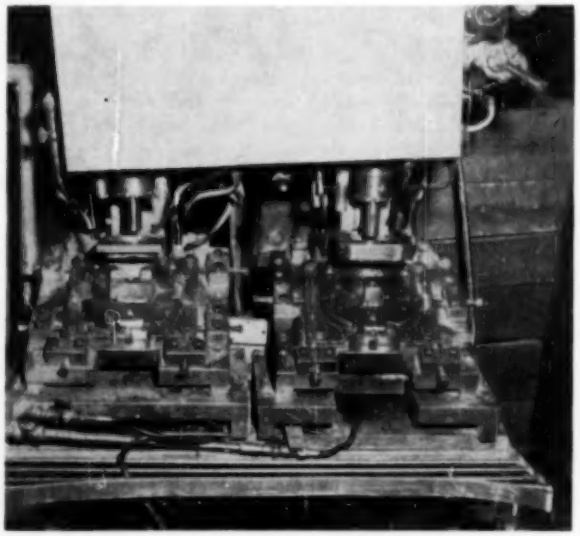

Figure 2—New Fixture with the Five Mounting Posts Used as Locating Pins for Boring the Cover Hole

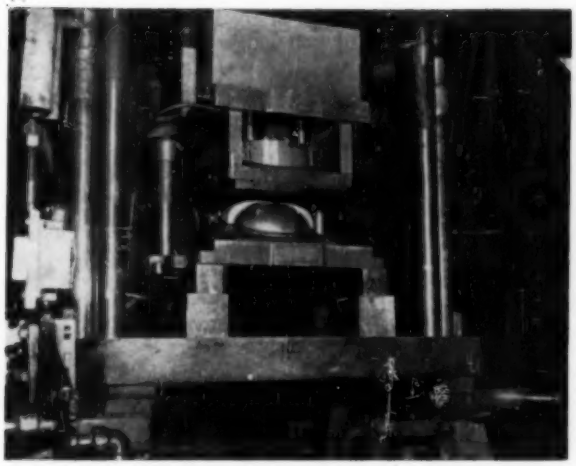

Figure 3—Obsolete Method of Die Trim Flash Removal

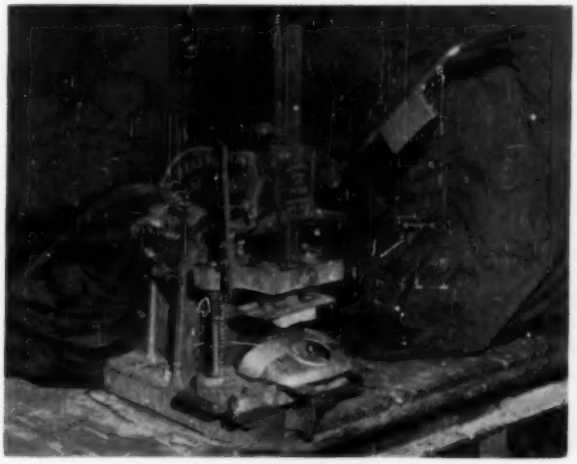

Figure 4—Second Phase of Obsolete Die Trim Flash Removal

Although the idea of the inspection plan was accepted, much effort had to be applied on new quality standards. These were finally agreed upon, final inspectors trained, and the quality level of shipments to Electrolux immediately started to improve. This was carried out on several parts simultaneously.

Third Step—Consumer-Vendor Shop Orientation

By former methods this would appear to be the end of a job, but present standards of management, increased production methods, etc., show that at this point mutual responsibility begins. With this in mind, the plant manager was contacted to discuss the complete orientation of key personnel and the elimination of rejections at the B company plant. Upon agreement, the plant manager, casting division superintendent, chief inspector, and others visited at Electrolux to obtain full knowledge of our processes, with particular emphasis on one part which was re-selected for reject elimination.

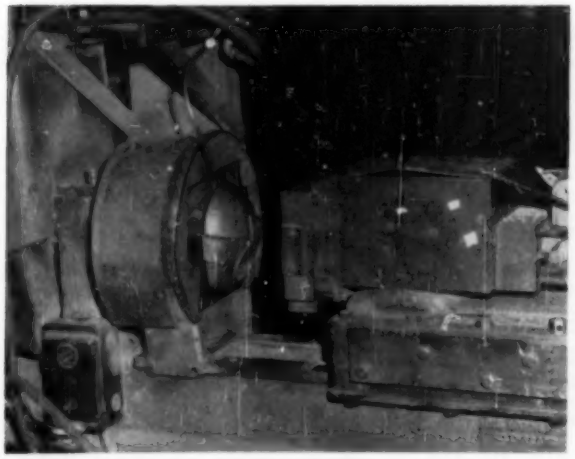

Figure 5—New Combined Method of Die Trimming and Facing

Fourth Step—Consumer-Vendor Job Selection

The first part selected was our cleaner front cover which requires a fine finish and acts as a mechanical base for opening and closing the dust bag chamber. The records showed that rejections were approximately 1.5% total for break-outs, warped castings, dented castings, and incorrect hole location. Warped and dented castings were traced to improper handling starting from the casting machine, and on through the method of shipment. Handling methods were adjusted to prevent warping and denting. Breakouts were improved by reorientation of trimming tools, but were not eliminated. Despite the efforts on breakouts and more vigilance on the "boring of the hole" location, rejects continued.

Fifth Step—Consumer-Vendor Methods Analysis and Correction

All the B company dies and processes were again mutually reviewed for elimination of rejects. After discussion, it was decided to change methods in two stages: first to correct the boring; and second, to avoid breakouts.

An analysis of the boring operation revealed that the cover was placed in a nest and located from an "air-fit" type of projection as shown in Fig. 1. This located the position of the bored hole which varied by the position in the one nest used to accommodate parts from several dies. No thought had been given to the relationship of the bored hole to the five mounting posts. Immediately it was decided to provide a new fixture which would use the mounting posts as a locating medium for boring. Figure 2 shows new fixtures for locating on five posts. When this was placed in operation, it immediately solved this cause of rejection.

To eliminate breakouts required more extensive alterations. Ultimately the casting dies were reworked to furnish a deeper casting. A new method of facing-off the excess metal was established to replace the die trim method. Figures 3 and 4 show two stage method of die trim flash removal which is now obsolete. Figure 5 shows new combined method of die trimming and facing. As a result of these activities, rejections have

now reached 0.2 percent total on this part. Rejections on other parts have also been reduced by a similar approach.

Sixth Step—Consumer-Vendor Preventive Inspection

In addition to this illustration, several preventive inspection ideas have been adopted. The most important of these is a parallel inspection plan for checking new dies and fixtures. In this plan, B company makes a sample inspection from all new tools, records its findings, and submits findings and sample parts for Electrolux to check. Using the same approach and gages, B company findings have been duplicated many times. After this work is done, the report is submitted to the engineering department for final approval before this die is placed in production.

Seventh Step—Consumer-Vendor Sampling

Sampling of B company's shipments starts at their plant where the shipper selects a random sample of each part, codes it, and places it in the shipment to facilitate easy handling at Electrolux. Upon receipt of a production shipment, the pre-selected samples are immediately sent into the Electrolux production line. These are given the regular production treatment with a report of findings for each operation on a prepared form which is returned to the receiving inspection station. Receiving inspection uses this form as their guide for inspection disposition of the shipment.

From these brief illustrations one can see that team work has been established and that product responsibility has been mutually assumed. Costwise, Electrolux has borne the cost of liaison while B company provided improvements in methods and tools at no cost to Electrolux. From a quick analysis of the one case illustrated, both companies can point to a $5,000 annual saving, due only to the reduction of rejects from 1.5 to 0.2 percent. The 0.2 percent figure may also be reduced, but at some time we will reach the point of no return.

Using the same steps, other mutual consumer-vendor applications have been made in the plastic, rubber, metal fabrication, and appliance fields.

A SUGGESTION TO LOCAL SECTIONS

Prepare a message for deliverey to all local members which will emphasize the consumer-vendor problem. Point out that most quality control men can only control the material which passes through their hands. The other two "M's" are under the control of the foreman (men) and the engineer (machine). A series of round table discussions would level the sights of members on the subject. In this fashion enough interest could be generated so that consumer-vendor relations would have a firm place in the yearly calendar of activities, and would take its place with other subjects for a monthly meeting topic. For these meetings, select speakers who are now using consumer-vendor programs.

DEVELOPMENT OF AN INDUSTRY-WIDE TECHNIQUE

As the mighty oak springs from the acorn, so will the consumer-vendor technique grow. The national officers of ASQC should sponsor this subject and promote the pooling of ideas. The final results from this pool of ideas could be incorporated in a standard procedure which, in due time, would be universally accepted as good business practice. Such a technique should be concise but broad enough to cover all industry and should be pointed toward control of purchased materials without interference with the prerogatives of the purchasing agent. In order that this subject be given proper treatment through the years, it is suggested that the national officers sponsor and form a standing committee to cover consumer-vendor relations.

Bibliography

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St. Louis 24, Mo.

BIBLIOGRAPHICAL

INTERNATIONAL JOURNAL OF ABSTRACTS ON STATISTICAL METHODS IN INDUSTRY, v. 1, n. 1, 1954
(Published by International Statistical Institute)

This is the first of a new periodical containing references to and abstracts of, articles on statical methods in industry. As this Journal is international in scope, many foreign publications, as well as American, are abstracted.

The first issue contains approximately 120 references under the following five classifications:

1. Process Control
2. Sampling and Acceptance Inspection
3. Research and Development
4. Administrative Applications and Operations Research
5. Management Applications

These are presented in a three by five card form so that these can be used for file systems if so desired.

APPLICATION—AIRCRAFT INDUSTRY

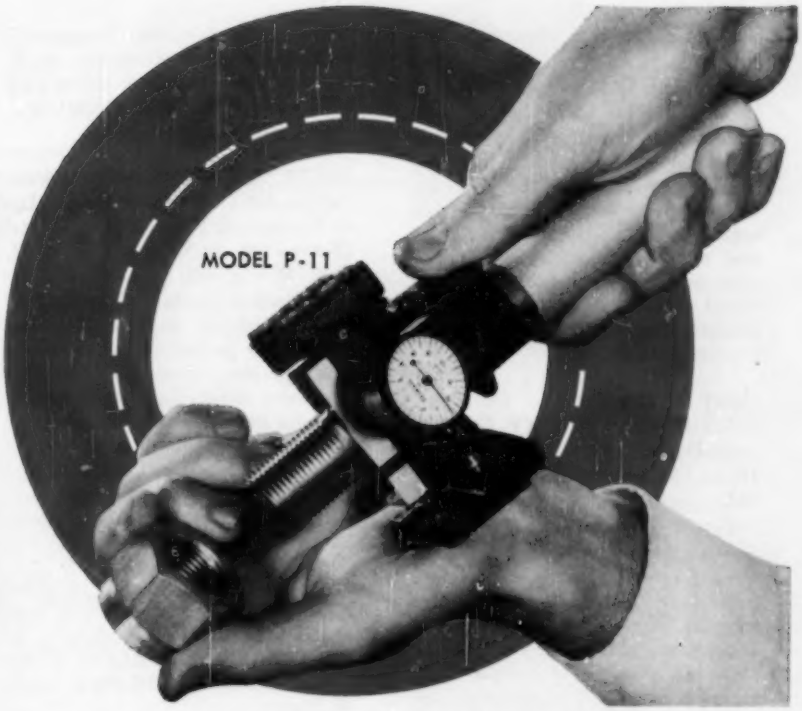
LIGHT METALS PROCESSING QUALITY CONTROL, H. Bourassa and W. Chellman
(Light Metal Age—v. 12, n. 1-2, Feb. 1954, p. 12)

Discusses a quality control program for machining aluminum and magnesium aircraft parts. Inspection records, process control, and equipment control are outlined. The classification of defects into the MIL-STD—105A categories of critical, major, and minor is indicated.

APPLICATION—CHEMICAL INDUSTRY

VACUUM FUSION ANALYSIS, W. S. Horton and Joseph Brady, Knolls Atomic Power Laboratory,

BRYANT GAGE FOR INTERNAL THREADS



The P-11 is a portable comparator gage. Variation from basic size of pitch diameter, form and lead are shown in a single reading on the dial indicator accurate to .0005". Interchangeable pairs of segments inspect all classes of threads in a range from 5/16" to 5" diameter.

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This gage is designed for use at the inspection bench or in the shop. It is used for quality control since complete control of the thread cutting process is possible. The indicator reading of variation from basic size tells exactly where within limits the work is running. For this reason also, the gage is used for checking tool wear in production jobs.

Please send descriptive literature covering the P-11 gage and other Bryant gages.

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General Electric Co., Schenectady, N. Y.

(Analytical Chemistry—v. 25, n. 12, Dec. 1953, p. 1891)

Certain statistical procedures are used to interpret analytical methods investigated by laboratory experiments. These techniques include analysis of variance and tests of significance, regression analysis and others. More detail given on the chemical and analytical procedure than on the statistical methods.

COST CONTROL IN THE CHEMICAL INDUSTRY, G. Malcolm Dyson

(Manufacturing Chemist, Feb. 1954, page 57)

This article discusses the effect of sampling and quality control in the internal economics of chemical industries. The problem of taking samples large enough to produce adequate determinations yet as small as possible is discussed in terms of frequency of sample. The analytical procedure necessary and the interpretation of results are also discussed.

APPLICATION—PETROLEUM INDUSTRY

EFFECT OF MULTITESTING ON REFINERY PRODUCTION COSTS, M. R. Morrow and C. T. Shewell, Refining Department, Humble Oil & Refining Co., Baytown, Texas.

(Ind. and Eng. Chemistry—v. 45, n. 1, Jan. 1953, p. 240)

Sampling of blends is necessary to assure the proper mixture. It is also necessary to sample enough to assure the proper mixture without excessive cost of sampling. A statistical approach to this problem is given. This includes measurement of various errors, studies of tolerances, and establishment of a final product quality level. An economy study of costs of testing, evaluation cost of tests and errors was made.

COMPARISON OF SPECTROCHEMICAL AND SEMIMICROMETHODS IN ANALYSIS OF PETROLEUM ASHES, G. V. Dyroff, John Hansen, and C. R. Hodgkins, Research Division, Standard Oil Development Co., P. O. Box 51, Linden, N. J.

(Analytical Chemistry—v. 25, n. 12, Dec. 1953, p. 1898.

The use of certain statistical methods where extremely small samples are available. Statistical tests include analysis of variance, F test, Bartlett's test, etc.

STATISTICAL QUALITY CONTROL, John F. Walter, University of Pittsburgh, Pittsburgh, Pa.

(Petroleum Refiner—v. 33, n. 2, Feb. 1954, p. 149)

Statistical charts are applied to a fractionating tower. This involves the problem of a continuous operation and the attending problems of rational sub-grouping. Moving averages and range charts were used. Examples of charts and results are given. Advantages and benefits are indicated. Additional use of the control charts to laboratory testing is also described.

APPLICATION—FOOD INDUSTRIES

AT GERBER'S QUALITY CONTROL REIGNS SUPREME, Lloyd E. Slater

(Food Engineering—v. 26, n. 1, Jan. 1954)

The organization and operation of quality control at Gerbers. Three stages of quality control—control of materials, control of process, and control of product. Quality control used to find better raw materials.

APPLICATION—TEXTILE INDUSTRY

A QUALITY-CONTROLLED PRODUCT IS A MORE SALEABLE PRODUCT, N. L. Enrick

(Textile Age—v. 17, n. 12, Dec. 1953, p. 35)

Mr. Enrick stresses the importance of quality control and of quality of product in developing customer acceptance and satisfaction. A chart showing the factors governing quality and the way specific problems may be solved is given. An outline indicates a detailed breakdown of problems and controls in a yarn mill.

APPLICATION—METAL WORKING

HOW TO DETERMINE QUALITY CAPABILITY OF MACHINES AND TOOLS, Harmon S. Bayer, Harmon S. Bayer & Associates, Quality Control Consultants, Detroit, Mich.

(Tooling and Production—v. 20, n. 2, May 1954, p. 41)

Mr. Bayer discusses in some detail an application of capability analysis to a battery of six-spindle Gridley Automatics. This problem involved the forming of an arc contour defined by two datum dimensions. The detailed discussion describes the data taken from each of the spindles and the analysis by means of frequency distributions (histograms). This original analysis is accompanied by average and range charts and the use of the normal curve of probability to estimate the portion of the production between given limits. This article is to be continued.

QUALITY PRODUCTS

(Production—v. 33, n. 4, Apr. 1954, p. 58)

This is a report of a round table discussion on the use of cleaning methods with controlled inspection. Production directors of eleven companies discusses their individual problems and opinion with emphasis on the cleaning of sheet metal materials.

APPLICATION—MISCELLANEOUS

JOURNAL OF FOREST PRODUCTS RESEARCH SOCIETY—v. III, n. 5, Dec. 1953

This publication includes the following articles:

"Translating Quality Control Facts into Action," William Price, Singer Manufacturing Company, South Bend, Ind.

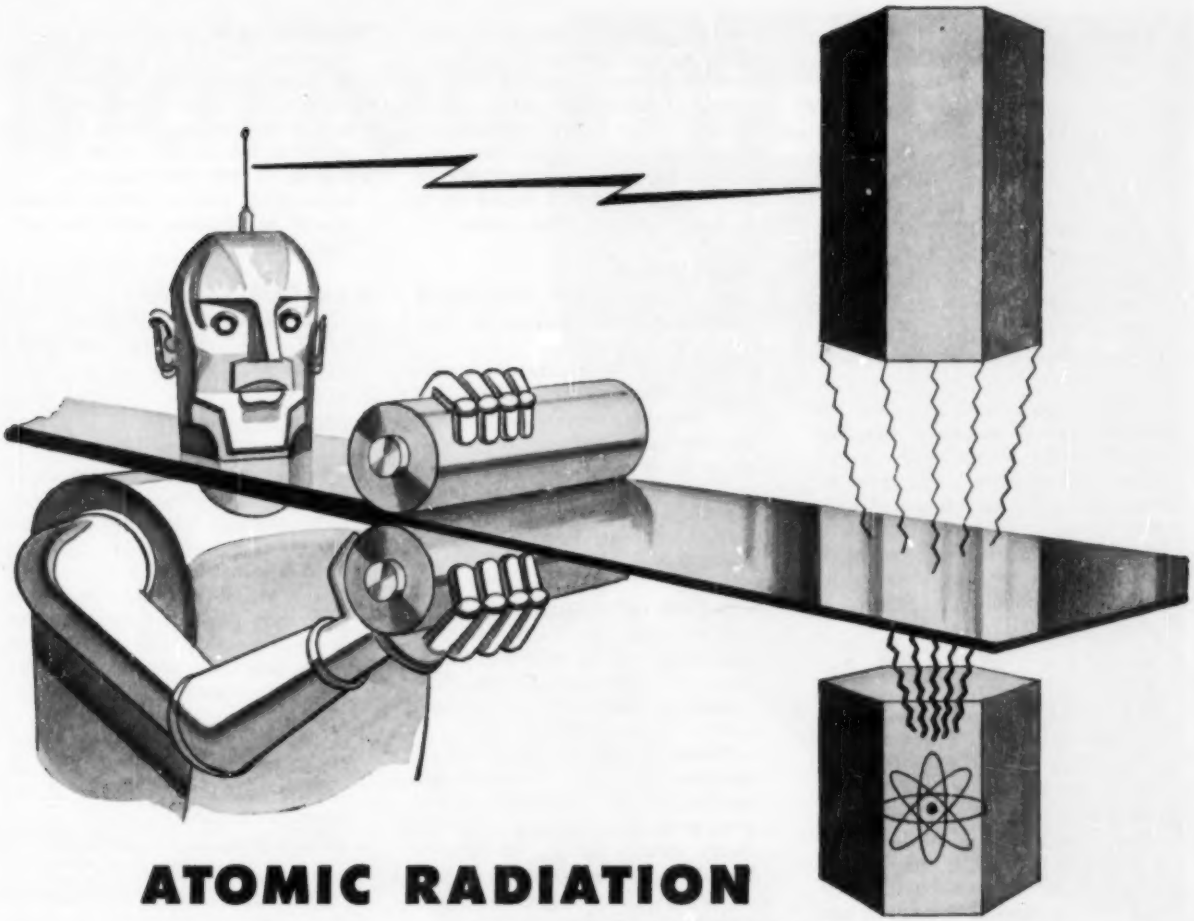
"Applications of Some Statistical Quality Control Techniques in the Manufacture of Veneer and Plywood," Edward P. McMahon, Nickey Brothers, Inc., Memphis, Tenn.

"Dimensions and Tolerances in the Machining of Wood Furniture Parts," James Bethel and Robert J. Hader, North Carolina State College, Raleigh, N. C.

"Survey of Grades in the Hardwood Plywood Industry," John L. Butler, Hardwood Plywood Institute, Atlanta, Ga.

"Statistical Methods and the Modern Quality Control Program," Carl E. Noble, Kimberly-Clark Corp., Neenah, Wis.

"An Application of Statistical Methods to the Thickness of Lumber Core Panels," John L. Lawlor, National Store Fixtures, Inc., Odenton, Md.



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"Quality Control in Furniture Manufacturing," Richard C. Calahan, Singer Manufacturing Co., South Bend, Ind.

"Some Applications of Statistical Quality Control to the Drying of Lumber," Willard E. Pratt, California Redwood Assoc., San Francisco, Calif.

"Effective Quality Control on End Product," Robert H. Ripley, Douglas Fir Plywood Assoc.

These include papers presented at a national meeting in Grand Rapids, Mich.

These various articles apply the techniques of statistical quality control to the Forest Products Industry as indicated in the titles of the articles. The techniques of control charts, quality reporting, analysis of tolerance, development of specifications, etc., are discussed in these various articles.

APPLICATION OF LAWS OF CHANCE TO PROBLEMS INVOLVING DEFECTS IN OPTICAL GLASS, John C. Young
(American Ceramic Society Bulletin—v. 33, n. 1, Jan. 1954, Part II)

The author gives a method of obtaining a greater percentage of striae free optical glass by using the laws of probability than can be obtained by conventional methods. An integrated inspection and processing technique was developed to accomplish this. Basic determination was on the redistribution of the striae when the glass was processed into optical elements of any specified size.

ASSURING A QUALITY PRODUCT, R. G. Cordes
(Refrigeration Engineering—v. 62, n. 1, Jan. 1954)

The General Electric Company has established a quality control method for checking its packaged air conditioners. A method of reporting has been used to reduce the number of leaks in systems. In general, article gives picture of quality improvement program as practiced by this division of General Electric.

HOW TO CONTROL THE FILL OF GRANULAR PRODUCTS, C. B. Way, The Green Giant Co.
(The Glass Packer—v. 33, n. 3, Mar. 1954, p. 31)

One problem in filling that is of great importance is the control of over-fill while at the same time providing an adequate amount. Procedures for evaluating the accuracy of fillers during operation as well as the overall results are presented. This procedure involves the statistical analysis of the variation of fills based on a normal frequency distribution.

CORRELATION

THE UTILITY OF MULTIPLE CORRELATION, Warren H Yarroll, Geneva Steel Co.
(The Mines Magazine (Colorado School of Mines), Feb. 1950, p. 21)

A detailed description of the purpose and procedure for multiple correlation is discussed. An example used is that of correlating tensile strength of steel with carbon content, magnesium, and thickness.

ANALYSIS OF VARIANCE

EXPERIMENTS WITH MANY FACTORS, K. A. Brownlee, University of Chicago, Chicago, Ill.
(Chemical Engineering Progress—v. 49 n. 11, Nov. 1953, p. 617)

Factorial experimental design is discussed in some detail. Detail explanations are given for several arrangements considering a relatively large number of factors. Details of the development as well as of the application of these techniques are described.

ENGINEERING AND EXPERIMENTS

MAKING ONE MEASUREMENT DO THE WORK OF TWO, W. J. Youden and W. S. Connor, National Bureau of Standards, Washington, D. C.
(Chemical Engineering Progress—v. 49, n. 10, Oct. 1953, p. 549)

Testing can be reduced to a minimum through statistically designed experiments. Examples of this are given. The problem of evaluating external factors is discussed. Some of the problems related to the selection of test samples and schemes for the selecting of such samples are discussed.

SAMPLING AND PAINT BRUSHES, M. J. Snyder, L. L. Lortscher, and G. H. Beatty
(American Society for Testing Materials, Bulletin No. 197, Apr. 1954)

This paper describes experimental work which provided additional assurance of lack of bias in sampling of paint brush fibers. Expected limits in the composition of random samples drawn from paint brush fibers were predicted on the basis of the known composition of the brush. Experimental testing of the plan supported the assumption that a random sample would be obtained with the procedure used.

MANAGEMENT AND PERSONNEL, GENERAL

MANAGEMENT USES OF STATISTICS, C. A. Bicking, S. J. Lorber
(Steel Processing—v. 40, n. 2, Feb. 1954, p. 108)

Presented before the Pittsburg Conference on Management Controls, October 1953. Management quality and management decisions can be controlled by statistical methods, as can other repetitive processes. Repetitive decisions can be made as well as single. In both cases, specific statistical (quality control) techniques can be applied.

NINE STEPS TO BETTER QUALITY, J. M. Juran, Consulting Management Engineer, Tuckahoe, N. Y.
(Factory Manage. and Maint.—v. 112, n. 3, Mar. 1954, p. 106)

Mr. Juran outlines and discusses nine steps necessary for a quality improvement campaign. These are:

1. Remove reject causes controlled by management
2. Set up a plant quality committee
3. Show operators how to improve quality
4. Solicit operators' ideas for improving quality
5. Convince operators of quality importance
6. Establish quality scoreboards and goals
7. Follow the scoreboard with your foremen
8. Set a start and end to your campaign
9. Follow through to make improvement permanent

HOW QUALITY CONTROL TOUCHES EVERYWHERE—AND GIVES HELP EVERYWHERE IT TOUCHES, L. O. Laabs, LeRoi Co., and C. R. Burdick, Houdaille-Hershey Corp.
(SAE Journal—v. 62, n. 4, Apr. 1954, p. 22)

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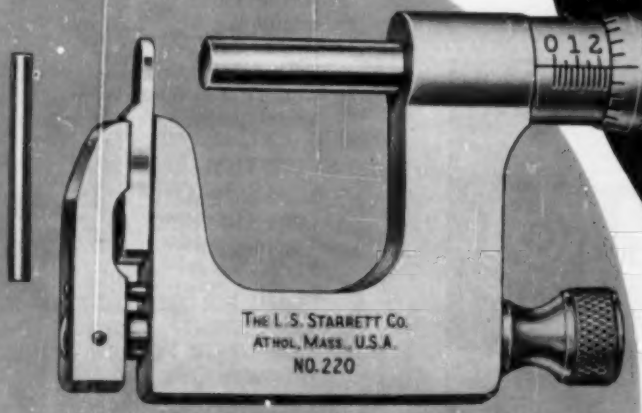

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PRECISION GROUND FLAT STOCK · HACKSAWS, BAND SAWS and BAND KNIVES
THE L. S. STARRETT COMPANY, ATHOL, MASSACHUSETTS, U. S. A.

This article discusses reasons for broader understanding and acceptance of quality control as expressed by the opinions of two SAE Production Forum Panels on this subject.

Some of the points are discussed under the following:
Aids Engineering
Likely to Cut Inspection Costs
Works Well on Short Runs
Applies to Visual Inspection
QC and the Foundry
QC and Assembly Operations
How to Install QC

INDUSTRIAL MANAGEMENT

MANAGEMENT'S RESPONSIBILITY FOR THE USE OF STATISTICAL TECHNIQUES IN INDUSTRY, W. Edwards Deming
(Advanced Management—v. 18, n. 11, Nov. 1953)

A general article dealing with the growth and development of statistical techniques in industry. The author shows that the statistical method is a way of management thinking, and describes how statistical control of quality can help a company's production efficiency. He also stresses the need for a good statistical organization.

THEORY AND APPLICATION—GENERAL

QUALITY CONTROL THROUGH STATISTICAL METHODS, Norbert L. Enrich, 7th of a Series
(Modern Textiles—v. 35, n. 4, Apr. 1954)

This article, which is the seventh in a series, deals with size and method of sampling in the textile industry. The method of calculating the desirable sample size is given.

The statistical techniques given would aid in the development of a testing program for a textile plant.

STATISTICS

NON-NORMALITY AND TESTS ON VARIANCES, by G. E. P. Box
(Biometrika—v. 40, Dec. 1953, p. 318)

SOME PROCEDURES FOR COMPARING POISSON PROCESSES OR POPULATIONS, A. Birnbaum
(Biometrika—v. 40, Dec. 1953, p. 447)

APPROXIMATING TO THE DISTRIBUTIONS OF MEASURES OF DISPERSION BY A POWER OF χ^2, J. H. Cadwell
(Biometrika—v. 40, Dec. 1953, p. 336)

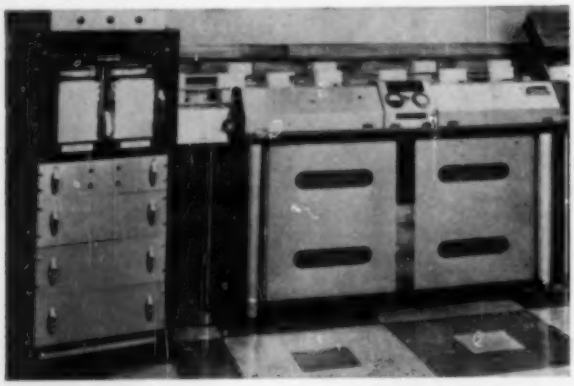
SOME SIMPLE APPROXIMATE TESTS FOR POISSON VARIATES, D. R. Cox
(Biometrika—v. 40, Dec. 1953, p. 354)

POWER FUNCTION OF SOME TESTS BASED ON RANGE, H. A. David
(Biometrika—v. 40, Dec. 1953, p. 347)

99.9 AND 0.1% POINTS OF THE χ^2 DISTRIBUTION, T. Lewis
(Biometrika—v. 40, Dec. 1953, p. 421)

GRAPHICAL METHOD FOR THE ANALYSIS OF STATISTICAL DISTRIBUTIONS INTO TWO NORMAL COMPONENTS, E. J. Preston
(Biometrika—v. 40, Dec. 1953, p. 460)

METHOD OF SYSTEMATIC SAMPLING BASED ON ORDER PROPERTIES, R. M. Sundrum
(Biometrika—v. 40, Dec. 1953, p. 452)



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MEASURE your entire production output—eliminate doubtful "sampling." The SELECTROL checks *every* unit produced. It automatically weighs, classifies, sorts, and records.

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MOMENTS OF THE RANK CORRELATION COEFFICIENT τ IN THE GENERAL CASE, R. M. Sundrum
(Biometrika—v. 40, Dec. 1953, p. 409)

SCALE FACTORS AND DEGREES OF FREEDOM FOR SMALL SAMPLE SIZES FOR χ^2 APPROXIMATION TO THE RANGE, G. W. Thomson
(Biometrika—v. 40, Dec. 1953, p. 449)

FREQUENCY JUSTIFICATION OF SEQUENTIAL TESTS, G. A. Barnard
(Biometrika—v. 40, Dec. 1953, p. 468)

APPROXIMATE CONFIDENCE INTERVALS, M. S. Bartlett
(Biometrika—v. 40, Dec. 1953, p. 468)

LIMITS OF MATHEMATICS IN STATISTICS, W. S. Woytinsky
(American Statistician—v. 8, n. 18, Feb. 1954, p. 6)

SAMPLING INVESTIGATION OF THE EFFICIENCY OF WEIGHTING INVERSELY AS THE ESTIMATED VARIANCE, W. G. Cochran, and S. P. Carroll
(Biometrics—v. 9, Dec. 1953, p. 447)

DERIVATIVE TEST FOR FINITE SOLUTIONS OF GAMES, I. Glicksberg
(Amer. Math. Soc. Proceedings—v. 4, Dec. 1953, p. 895)

TABLES OF PEARSON-LEE-FISHER FUNCTIONS OF SINGLY TRUNCATED NORMAL DISTRIBUTIONS, A. C. Cohen, Jr. and J. Woodward
(Biometrics—v. 9, Dec. 1953, p. 489)

SEQUENTIAL ESTIMATION, F. J. Anscombe
(Royal Statistical Society, J. 1, B, —v. 15, n. 1, p. 1)

THEORY OF INFINITE GAMES, S. Karlin
(Annals of Mathematics—v. 58, Sept. 1953, p. 371)

DOUBLE SAMPLE TEST PROCEDURE, D. B. Owen
(Annals of Math. Stat.—v. 24, Sept. 1953, p. 449)

REPORTED—NOT REVIEWED

STATISTICAL QUALITY CONTROL—A NEW TOOL FOR THE ELECTROPLATER, E. A. Blount
(Plating—v. 40, Aug. 1953, p. 868)

STATISTICAL ANALYSIS OF MICRO-GEOMETRICAL IRREGULARITIES OF MECHANICAL PARTS, M. Cave
(Microtecnic—v. 7, n. 5, 1953, p 227)

BIBLIOGRAPHY OF NONPARAMETRIC STATISTICS AND RELATED TOPICS, I. R. Savage
(Amer. Stat. Assoc. Journal.—v. 48, Dec. 1953, p. 844)

COMPOSITE MEAN SQUARES AND THEIR DEGREES OF FREEDOM, L. P. V. Johnson and E. S. Keeping
(Applied Statistics — v. 1, Nov. 1952, p. 202)

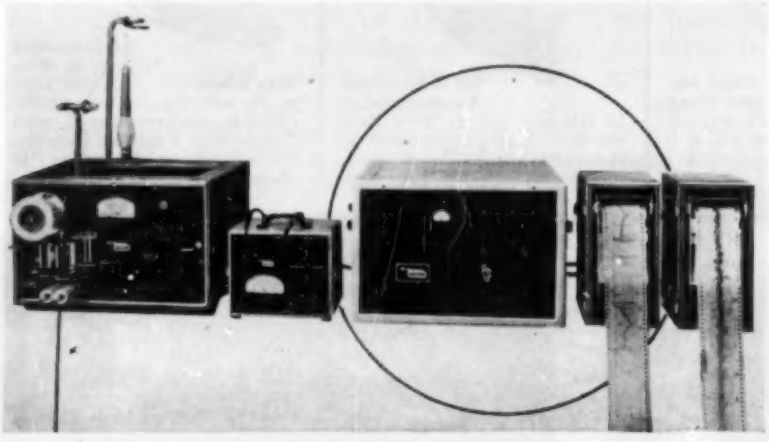
INVENTORY PROBLEM, J. Laderman, S. B. Littauer, and L. Weiss
(Amer. Stat. Assoc. Journal—v. 48, Dec. 1953, p. 717)

What's New?

ROY A. WYLIE, *Editor*

News releases describing new products and literature should be sent to:
George R. Foster, Mng. Ed.
Room 6123 Plankinton Bldg.
161 W. Wisconsin Ave.
Milwaukee 3, Wis.

The Uster Spectrograph for use in conjunction with the Uster Universal Evenness Tester has recently been announced by the **Uster Corporation** of Charlotte, N. C. This Spectrograph picks out and charts the repeat patterns of unevenness in yarn, roving, sliver or picker laps that are caused by defective machinery or manufacturing methods. These unevenness repeats, which are a primary cause of defective fabrics, may now be quickly and easily located and the necessary corrections made.



Operation of the Uster Spectrograph is simple compared to previous repeat interpretation methods. A complete test is automatically made by placing the Uster Tester and Spectrograph in operation for the period of a little over one minute. The recorder chart is read and the position of the defective machine parts located by the simple extension of a line.

★ ★ ★ ★ ★

An accessory to their Dial Bore Gage has been announced by **Boice Manufacturing Company,** Staatsburg, New York. It is the Dial Bore Gage Set Master, an adjustable setting master that can be set up with gage blocks, locked and sealed, and used on the job. The gage blocks used for setting are returned to storage after the master is set up. A built-in equalizer positions the gage so that it is necessary to rock it in one plane only to establish the

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How to Cut the Cost of Plain Fixed Gages

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The *best* gage for most jobs provides the *best* combination of speed, wear-resistance, upkeep, and initial cost. Here are some comparisons that will help you keep costs to a minimum.

Plain Plugs

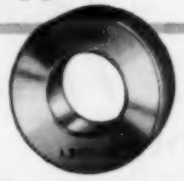
T-P Cylindrical Plug Gage. Furnished with "Go" and "Not Go" separately, or on opposite ends of handle. Progressive gage — with "Go" and "Not Go" on same end increases speed.

T-P Electrolized Plug Gage. With only a modest increase in initial cost, substantially longer wear life can be obtained with this exclusive surface treatment. Many users report up to 3 times longer gage life.

T-P Carbide, Norbide, Chromium Plated Gages. For exceptional resistance to abrasion or scratching and maximum wear life. Furnished in both standard and special sizes — from #8 machine screw size up.

Plain Rings

T-P External Ring Gage. For reference purposes, setting air or other variable gages and accurate size control of parts.



T-P Chromium-Plated Ring. Lowers gaging costs on longer runs of highly abrasive materials or hardened steel. Provides up to 5 times more service.

T-P Norbide and Carbide Rings. For greatest wear-resistance. Available in Norbide and Tantalum or Tungsten Carbide. Brittleness requires careful handling.

Adjustable Snaps

T-P Plain Adjustable Snap Gages. Available with gaging pins, round or square buttons, and solid anvils in combination with buttons.

T-P Midget Snap Gages. Smaller in size and section, their light weight aids in gaging small or delicate parts. Maximum rigidity and stability are provided.

T-P Cemented Carbide or Norbide Snaps. For close tolerance work on abrasive materials. Gaging members tipped with Tungsten or Tantalum Carbide. Or with Norbide inserts, as shown.

For the complete story on these items and many more, send for your copy of the Taft-Peirce Handbook.

Gage Blocks Plain Gages Thread Gages Ratochek

T-P means Top Precision

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New Taft-Peirce CompAIRator Air Gage

Measures and Computes

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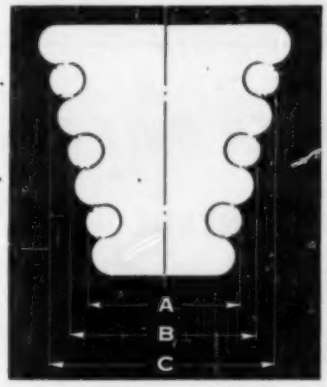
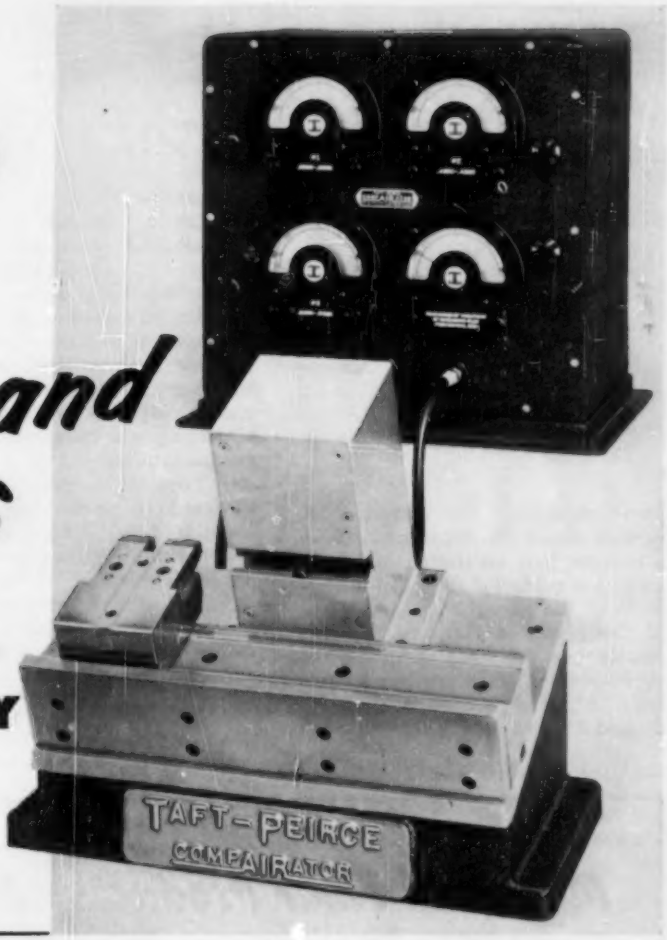


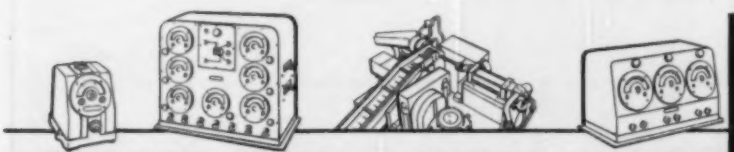


The CompAIRator above checks serrations in the root section of jet engine turbine blades. Does automatically and instantly what formerly took skilled hands many minutes to do.

Three of the air indicators measure thickness "over rolls" of the serrated sections. At the same time, a T-P Computing CompAIRator computes the difference between two of these dimensions and compares it to a standard value. If the variation is greater than plus or minus .001" on the dial, the part is rejected. Most important of all, the serrations can be checked over their entire length.

Two different models of this gage have been built. One permits gaging with the part in the grinding fixture — thus eliminating many costly rejects. The other serves as a final inspection gage.

This unit is typical of the hundreds of Taft-Peirce CompAIRators now simplifying complicated gaging operations. For more information on this and many other items, send for your copy of the Taft-Peirce Handbook.



STANDARD AND SPECIAL COMPAIRATORS | AIR ELECTRIC COMPAIRATORS | AUTOMATIC SORTING MACHINE | COMPUTING COMPAIRATORS

T-P means Top Precision

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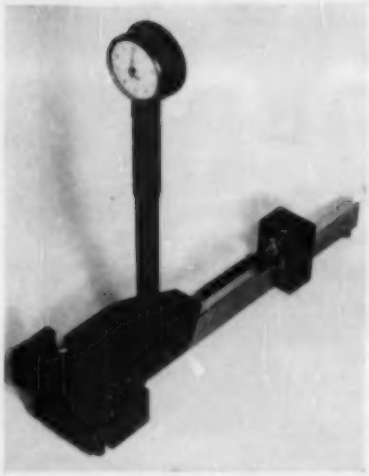

zero reading on the indicator. A carbide insert on the wear surface, a positive lock on the movable anvil and a guide for the quick alignment of the gage blocks are a few of the pertinent features. The set master has the same range as the corresponding gage model, as follows: 1" to 1¾", 1¾" to 3", 3" to 6", and 6" to 13".

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A gage for measuring the diameter of internal grooves, such as "O" ring, snap ring, Truarc, etc., is being manufactured by **Federal Products Corporation**, 1144 Eddy Street, Providence 1, R. I. It is adjustable from 0.725" to 2.625" and the contacts are located at the extreme ends of the gage arms to make it possible to check grooves at the bottom of blind holes. The reference of fixed contact is on the lower arm in order that neither the weight of the gage nor any pressure from the operator's hand will affect the reading. A sensitive movement in which a one-to-one lever pivots in ball bearings gives repeat readings and maintains accuracy.

In operation, the trigger is squeezed to retract the upper, or sensitive anvil. The jaws are then inserted into the bore and when the trigger is released, the contacts seat themselves in the grooves. A slight rocking motion positions the contacts accurately at the maximum diameter of the groove.

★ ★ ★ ★ ★

An air gage for inspecting set engine airfoil strip stock for thickness, width and camber at a rate of 30 feet per minute is announced by **The Sheffield Corporation**, Dayton 1, Ohio. As the metal stock passes through the gaging station, thickness is gaged at five places, and width at one with Plunjet gaging cartridges. The amount of camber in any 12-inch section of stock is gaged by a Plunjet located midway within this length.

During gaging, the operator watches the positions of the floats in the twelve Precisionaire columns to determine whether the dimensions and conditions are in tolerance or how much they are out of tolerance. Minimum and maximum tolerance lines show at a glance whether the stock is in or out of tolerance. Interchangeable and adjustable tooling is provided to permit checking of four different widths of stock. Two motor driven rolls are used to move the stock through the gage and a two-speed transmission controls the speed of the rolls. The stock movement may be stopped and reversed at any time, thus enabling the operator to reinspect any section.

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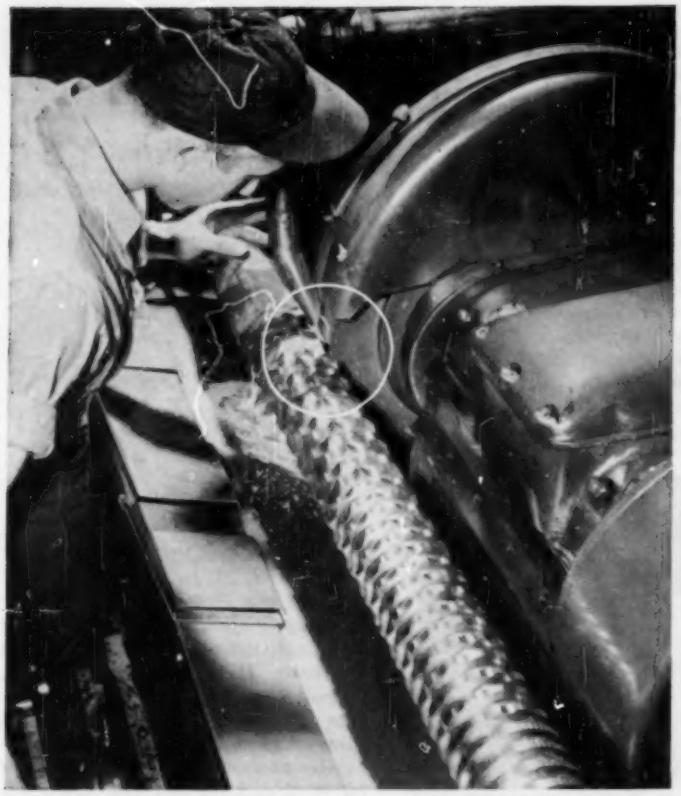
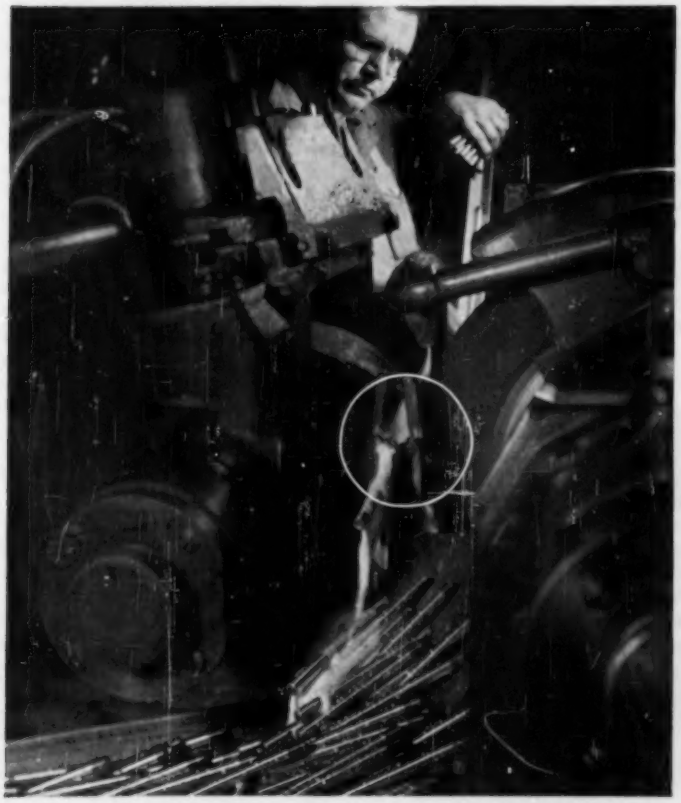


"Best Wheel Ever Used," reported by a user of Norton G Bond wheels for cylindrical grinding, sums up the industry-wide verdict.



"G Bond Wheels Cut Faster, with twice as many pieces per dressing," says a customer reporting on a centerless grinding application.

PROOF that O.D. grinding gets the "TOUCH of GOLD" with Norton G BOND wheels

. . . "Free cutting, excellent finish, considerably reduced grinding time."

. . . "Gave more than three times as many pieces per dressing."

. . . "Formed easily, held shape and removed .078″ per plunge cut."

Reports like these are coming in fast from our O. D. grinding customers using the new Norton G Bond wheels — now chalking up sensational records for more units per dressing, per hour and per wheel.

That's because of the new G Bond's unique ability to hold each abrasive grain *just long enough* for maximum cutting action. Wheels made with it cut cooler . . . remove material faster . . . produce a better finish . . . produce more pieces per dressing . . . hold shape longer . . . and crush-true more easily.

Quality Control is an important reason for Norton superiority. From the moment that the abrasives, bonds and other raw materials enter the mile-long Norton Worcester plant until the completed grinding wheels are shipped, quality control plays an important part in their manufacture. Norton Company, Worcester 6, Mass. Warehouse in Five Cities – Distributors in All Principal Cities.

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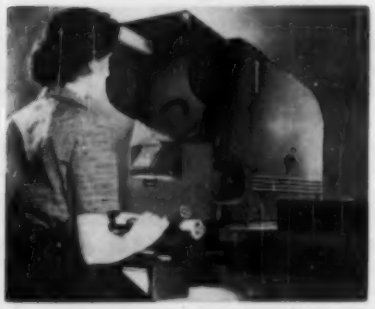
Making better products . . . to make other products better

Standard Gage Company, Inc., Poughkeepsie, N. Y., has announced a new development in its line of Dializers. Dializers convert standard (AGD) adjustable limit snap gage frames to dial snap gages and have been available with a 1⅛" diameter indicator. The new Dializers have either a 1¾" or 2¼" diameter indicator. Indicator graduations of .001", .0005", .00025" and .0001" are available. The range has also been increased. The smallest indicators are hooded and the larger ones have protective guards designed to allow the gage to be placed on either side or stood on its end without resting on the indicator case.

Dializer bodies are produced in three sizes to conform to the different hole spacings, depending on the size of the frame, in the AGD standards. Any one of the three sizes may be equipped with any of the indicator sizes. Dialized snap gages can be made up from AGD snap gage frames of any make to measure diameters up to 11⅝". With special frames available from Standard Gage Company, diameters up to 26⅝" can be measured. Dializers will convert AGD adjustable limit length gages also to dial instruments which can be used for internal as well as external measurements if the progressive type is used.

★ ★ ★ ★ ★



Among the items displayed at the ASQC Convention in St. Louis by the **DoAll Company**, 254 North Laurel Avenue, Des Plaines, Illinois, was the new Bausch & Lomb optical bench comparator with understage illumination. The lighting unit is located below the stage, making the stage itself completely accessible, directly in front of the operator, eliminating the need for elaborate fixtures. Simple locating stops suffice for many large volume inspection operations. Focusing is by means of a single adjustment knob, and the comparator is designed for fast comparison of precision parts against master charts on either large volume quality control operations or short-run inspections.

The viewing screen is 10" in diameter and interchangeable lenses provide magnifications of 10X, 20X, 25X, 31¼X and 50X. Through the addition of a measuring stage with .0001" graduated micrometer drums, the projector may be used as a measuring instrument. The regular stage or work table is 6" x 10", while the measuring stage has a 1" x 2" movement.

★ ★ ★ ★ ★

A new pocket size thickness gage for measuring non-magnetic protective and decorative coating on ferrous metal bases is being distributed by the **Ferro Corporation** of Cleveland, Ohio. The instrument will measure such films as porcelain enamel, platings, paints, foils, plastic sheetings, leather, glass, paper, rubber, lacquer, etc. The Elcometer relies upon a strong permanent magnet for its operation, and can therefore be used independent of a power supply. A locking device permits reading of the scale after measuring an inaccessible area where the scale cannot be seen.

★ ★ ★ ★ ★

An AC Voltage Standard is available from **Sorensen & Co., Inc.**, 375 Fairfield Avenue, Stamford, Conn. It is designed specifically for calibrating meters and oscilloscopes, uses no tubes, is small in size and weight, and extremely stable. The instrument can be used for direct checking and calibrating of vacuum tube voltmeters and for indirect checking of power meters. Specifications are as follows:

Range: 1 mv to 100 mv,
100 mv to 1 v,
1 v to 10 v

Accuracy: ±0.25%

Input: 115 VAC ± 10%, 1 phase, 60 cycles.

Output loading: 1 megohm or higher. The output may be short circuited without damaging the instrument.

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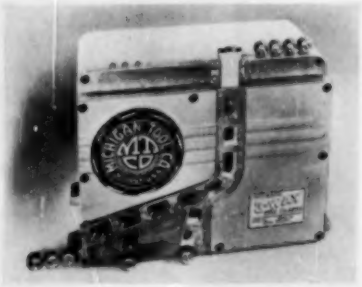
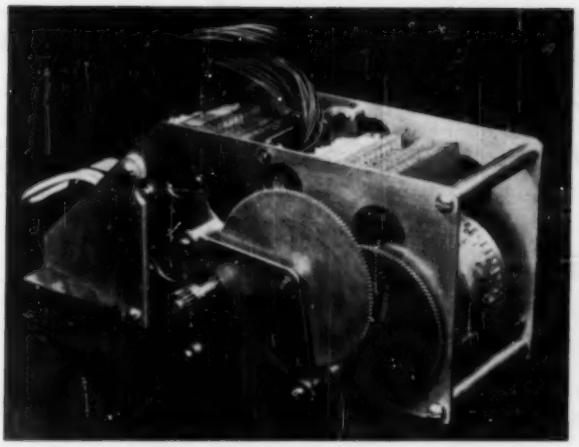


An automatic gear selector is being manufactured by **Michigan Tool Company**, 7171 E. McNichols Road, Detroit 12, Michigan. It will segregate 100 percent of gears produced into satisfactory, oversize and undersize at a rate faster than they can be produced on shaving machines, hobbing machines, gear shapers, shear-speed gear shapers or any other cutting or finishing machine. Gears may be fed into the machine by an operator, or gears may be inspected in a fully automatic setup without requiring an operator. An additional feature is that the unit can be furnished with an automatic shut-off, coupled with a counter, to stop the production machine if any number of consecutive gears (number is optional) are rejected, or the percentage of rejects on a given run exceeds set limits.

Two master gears, one of which is motor driven, are used to check the gears being produced. The gears being checked are passed between the motor driven fixed master gear and a second pivoted master gear. The pivoted gear moves in or out as required to stay in contact with the gear being checked. If the movement is within the prescribed limits, the gear after inspection, rolls down an incline and is deposited in a tote pan or conveyor to be transported to the next operation. If it is oversize or undersize, the gear is diverted by the closing of a mechanically operated baffle to its proper rejected classification exit at the bottom of the selector.

★ ★ ★ ★ ★



The Data Reduction and Automation Division of Fischer & Porter Co., Hatboro, Pa., announce a new digital converter to convert the analog output of primary sensing devices—such as flow meters, thermocouples or pressure transducers, etc. —into a digital signal. Digital signals, represented by discrete contact positions in the Digi-Coder are the input to electric typewriters, digital computers, punch card equipment and other data handling equipment.

Two basic types of Digi-Coder are offered. One type converts a mechanical motion, delivered to its input shaft from a pneumatic or other receiving mechanism, into a digital output signal. Torque requirements are less than .20 inch-ounce. The second type of Digi-Coder, which contains an integral self-balancing potentiometer, converts an analog voltage input into the digital signal. The voltage-input type will operate on a 0-1 millivolt input and up, with either linear or non-linear relationship maintained between input and output signals. The conversion is accomplished by purely mechanical means without complex components. The device can operate at speeds up to 5,000 counts per second.

NEW LITERATURE

"Boremaster" brochure, describing a series of new, low cost ring gages designed especially for setting dial bore gages, air gages, and other types of inside measuring devices. Size Control Company, 2500 West Washington Blvd., Chicago 12, Illinois.

A slide rule Gage Selector for the proper selection of pitch diameters for all American or Unified thread plug or ring gages. Sheffield Corp. Gage Division, Dayton, Ohio.

TIC Laboratory Report No. 9 described applications of the Type 310-A Z-Angle Meter and the Type 320-AB Phase Meter in school laboratories and suggests methods of use for certain instruments to simplify common electrical measurements for students. Technology Instrument Corporation, 531 Main Street, Acton, Massachusetts.

A four-page pamphlet on Scherr Micrometers includes illustrations of micrometers being adjusted for wear, of micrometers being checked for accuracy with gage blocks and for parallelism with optical parallels, a Tool Stand used for clamping a micrometer, Micrometer sets in various combinations, and Depth Micrometers. George Scherr Co., 200 Lafayette Street, New York 12, N. Y.

A 52-page booklet on statistical quality control has been published by Marchant Calculators, Inc. The booklet is a comprehensive case history of the successful application for statistical quality control to Marchants' extensive manufacturing operations. It covers all phases of the manufacturing picture—design, engineering, purchasing, planning, tooling, production, production control, inspection and management. While the booklet was created primarily for internal use, at the same time it is a "meaty" handbook which presents graphically an overall program and specific quality control procedures that can serve as guides for other companies. The booklet is available free of charge to interested concerns and individuals. Marchant asks that requests for copies be submitted on company letterheads, addressed to Marchant Calculators, Inc., Oakland 8, California.

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ELLIS R. OTT, *Editor*

Send your "Practical Aid" contribution to:
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New Brunswick, N. J.

Statistical Aids in Locating Machine Differences

SUNDARI VASWANI
Ahmedabad Textile Industries Research Association, Ahmedabad, India

ELLIS R. OTT
Rutgers University New Brunswick, N. J.

Summary

An observed set of data can often be analyzed in more than one way. In this paper, four methods of analyzing a set of observations following a Poisson distribution are given. All of these methods were found to lead to rather similar conclusions.

The Problem

An excessive number of breaks in spinning was being experienced in a textile mill. It was decided to make an initial study to determine whether there were any essential differences in the behavior of the *machines*. Rather than to take all the samples at one time, it was decided to use random time intervals of 15 min. until data were on hand for ten such intervals.

Each spinning machine (frame) contains 176 spindles. As soon as a break occurs on a spindle, the broken ends are connected or "pieced" together and spinning resumes on that spindle. (The remaining 175 spindles continue to spin during the repair of a spindle.) Thus the number of end-breaks during any 15-min. interval is theoretically unlimited, but we know from experience that it is "small" during ordinary production. The distribution of end-breaks may therefore be assumed as Poisson.

The selection of a 15-min. interval was an arbitrary decision for the initial study. Similarly, it was decided (arbitrarily, based on what was practical) to include eight machines in the initial study.

The number of end-breaks in 15 min. per side of 176 spindles is shown in Table I.

TABLE I

Sample No.	Frame No. 1	2	3	4	5	6	7	8	Total	Machine Ave.
1	13	7	(22)	15	20	(23)	15	14	129	16.1
2	18	10	7	12	19	17	18	(22)	123	15.4
3	8	8	(21)	14	15	16	8	8	98	12.2
4	13	12	8	10	(23)	△3	12	20	101	12.6
5	12	△6	9	(27)	(32)	△4	9	18	117	14.6
6	△6	△6	△6	17	(34)	12	△1	(24)	106	13.2
7	16	20	△5	9	8	17	7	(21)	103	12.9
8	(21)	9	△2	13	10	14	7	17	93	11.6
9	17	14	9	(24)	(21)	8	△6	(33)	132	16.5
10	16	7	7	10	14	10	△6	11	81	10.1
Sample Ave.	14.0	9.9	9.6	15.1	19.6	12.4	8.9	18.8	Grand Ave.	13.51

Analysis I

In the Poisson distribution, $\bar{c} = 13.54$ and $\sigma' = \sqrt{13.54} = 3.68$. Let us consider *individual* behavior at an arbitrarily selected level of 2σ, since we are anxious to detect possible sources of trouble.

$$UCL = 13.54 + 2(3.68) = 20.90 \text{ (figures in circles)}$$

$$LCL = 13.54 - 2(3.68) = 6.18 \text{ (figures in triangles)}$$

Conclusion: A visual inspection of the individuals so marked suggests:

A) Machines 4, 5 and 8 are suspiciously bad; there are *circles* in each column and *no triangles*.

B) Machines 2 and 7 look good; there are at least *two triangles* in each and no circles. (Machine 3 shows excellent performance except for the two circled readings.)

Analysis II

Same as I, except let us consider 2-σ control limits for machine *averages* (see Fig. 1). If n = 10,

$$\sigma_{\bar{c}} = 3.68/\sqrt{10} = 1.16$$

$$UCL_{\bar{c}} = 13.54 + 2(1.16) = 15.86$$

$$LCL_{\bar{c}} = 13.54 - 2(1.16) = 11.22$$

Conclusions: From Fig. 1 we see that there is an appreciable difference between machines; those outside of the 2-σ limits are:

Bad ones: Machines 5 and 8

Good ones: Machines 2, 3 and 7

This is in substantial agreement with Analysis I.

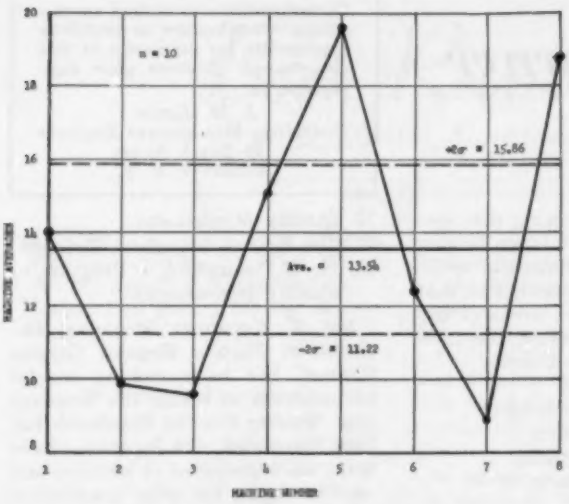

Figure 1—Analysis Based on Machine Averages

Analysis III (Analysis of Variance)

TABLE II

Source	d.f.	Sum of Squares	Mean Sum of Squares	F
Between frames	7	1186.4	169.5	4.43
Within frames	72	2759.5	38.3	
Totals	79	3945.9		

Since F = 4.43 is significant at the one percent level ($F_{.01} = 2.90$) and corrective action has to be taken on the frames giving high breaks, isolating frame No. 5 we get, for frames 1 to 4 and 6 to 8:

TABLE III

Source	d.f.	Sum of Squares	Mean Sum of Squares	F
Between frames	6	766.3	127.7	3.82
Within frames	63	2105.1	33.4	
Totals	69	2871.4		

Again F= 3.82 is significant at the one percent level so isolating frame Nos. 5 and 8, we have, for frames 1 to 4 and 6 to 7:

TABLE IV

Source	d.f.	Sum of Squares	Mean Sum of Squares	F
Between frames	5	328.1	65.6	2.14
Within frames	54	1655.5	30.6	
Totals	59	1983.6		

F = 2.14 is not significant at the five percent level.

Conclusions: Frames 5 and 8 give significantly higher breaks than the rest. If a similar analysis of variance is performed isolating the frames giving the lowest breakage rate at each stage, it will be seen that frames 2, 3 and 7 form a homogeneous group giving the lowest breaks. Once again the conclusions are:

Bad frames: 5 and 8

Good frames: 2, 3 and 7

This agrees with Analysis II (see Fig. 1).

Analysis IV (Chi-square, χ^2, Analysis)

The average number of breaks per machine is 10 x 13.54 = 135.4. With this value as the "theoretical" or "expected" number of *breaks per machine*, we compute χ^2 to be

$$\chi^2 = \frac{\sum_{i=1}^{8} (F_i - T_i)^2}{T_i}$$

where F_i is the observed number of breaks per machine, T_i is the "theoretical" number of breaks.

The critical value of χ^2 at the one percent level with seven degrees of freedom is 18.5. From Table V it is seen that

$$\chi^2 = \frac{\Sigma\Delta^2}{T} = \frac{11{,}863.88}{135.4} = 87.62$$

Conclusions: From this analysis it is concluded that:

A) The differences between machines are important

B) Machines 5 and 8 contribute most of the "bad" effect to chi-square

C) Machines 2, 3 and 7 are particularly "good"

Again it should be noted that the chi-square analysis substantiates the conclusions of Analyses I, II and III.

Corrective Action

As a result of these analyses, an investigation was conducted on frames 5 and 8 which revealed among other things defective roller coverings and settings. Corrective action resulted in a reduction in average breaks to 11.8 and 8, respectively.

A study of the reasons for the superior performance of machines 2, 3 and 7 is continuing and promises to give results of even more importance than the correcting of the defective machines.

TABLE V

Machines	Between Machines F_i	T_i	$\Delta = (F_i - T_i)$	Δ^2
1	140	135.4	4.6	21.16
2	99	135.4	−36.4	1324.96
3	96	135.4	−39.4	1552.36
4	151	135.4	15.6	243.36
5	196	135.4	60.6	3672.36
6	124	135.4	−11.4	129.96
7	89	135.4	−46.4	2152.96
8	188	135.4	52.6	2766.76
				$\Sigma\Delta^2 = 11863.88$

Management's Corner

J. M. JURAN, *Editor*

Correspondence is invited on potential contributions or problems appropriate for discussion in this department. Address your suggestions to:

J. M. Juran
Consulting Management Engineer
195 Beech Street
Tuckahoe, N. Y.

This department is spending July and most of August, 1954, in Japan at the invitation of Nippon Kagaku Gijutsu Renmei (Union of Scientists and Engineers of Japan).

The itinerary involves primarily two 10-day lecture series for industrial supervisors and executives. One of these series will be conducted in the Tokyo area, the other in the Osaka area.

In each of these same areas, one or two-day seminars will be conducted, for heads of companies, on the responsibilities of top management in quality control.

Additional seminars will be conducted for a group of professors and instructors assigned to attend the lectures and to become the means for propagating the subject matter in the years to come.

Finally, there will be visits to various plants to study Japanese practice and to appraise it.

The invitation proposing this lecture series noted that Japan is now self-sufficient as to statistical techniques for quality control, and that the need was in other areas of the subject. With this in mind, the titles of the lectures are as follows:

1. Nature of Control
2. Perspective of the Subject
3. Economics of Quality
4. Specification of Quality
5. Manufacturing Planning for Quality
6. Production Department Quality Problems
7. Organization for Inspection
8. Measurement
9. Vendor Inspection and Control
10. Process Inspection and Control
11. Final Inspection, Test and Control
12. The Staff Quality Functions.
13. Defect Prevention
14. Quality Assurance
15. Training for Quality
16. Quality-Mindedness
17. The Role of Statistical Methods
18, 19, 20. Launching a Program of Quality Improvement

Mr. K. Koyanagi, Managing Director of Nippon Kagaku Gijutsu Renmei, has been making careful preparations to bridge the language gap. Quality Control Handbook has been translated into Japanese. Lectures were prepared in advance and sent to Japan for prior translation. These precautions have been buttressed with the provision of an interpretation service, plus a "lecturing machine" which will permit projection of the lecturer's words, diagrams, charts, etc., as he writes them, so that they will be easily visible to the substantial audiences involved.

This department will, in some future issue of IQC, report on observations of Japanese practice.

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Book Reviews

A. C. COHEN, Jr., *Editor*

Correspondence and suggestions concerning book reviews should be sent to:
Professor A. C. Cohen, Jr.
Department of Mathematics
University of Georgia
Athens, Ga.

BINOMIAL, NORMAL, AND POISSON PROBABILITES, Ed. Sinclair Smith; Published by the author, Box 224C, RD2, Bel Air, Maryland, 1953. 71 pp. (paper) $2.50.

This monograph includes ten tables, seventeen graphs and a collection of formulas, which according to the author, will enable one to determine readily cumulative binomial probabilities to within 0.001 for p from 0.001 to 0.999, for $n > 20$. Among the tables included are five place tables of binomial, normal and Poisson probabilities, ten place tables of log n, e^{-x}, n!, log n!, and five place tables of $\binom{n}{x}$ and log $\binom{n}{x}$.

A.C.C.

50-100 BINOMIAL TABLES, Harry G. Romig; John Wiley and Sons, Inc., New York, 1953. xxvii + 172 pp. (cloth) $4.00.

These are six decimal tables of individual and cumulative terms of the binomial distribution with n ranging from 50 to 100 in steps of five. Entries are given for values of p from 0.01 to 0.50 in steps of 0.01, and of course terms of the distribution for p from 0.51 to 1.00 can be readily obtained from those given. The introduction includes a definition of the binomial distribution, a discussion of its relation to the hypergeometric and incomplete beta function, an explanation of the notation used in the tables, a description of procedures used in computing the tables, remarks concerning their accuracy and directions for using the tables and for interpolating into them, together with illustrative examples.

A.C.C.

CUMULATIVE BINOMIAL PROBABILITIES, PB111 389; Available from Office of Technical Services, Commerce Dept., Washington 25, D. C., 1952, viii + 577 pp. (paper) $6.00.

Of all the binomial tables published to date, these are the most extensive. For n from 1 to 150 in steps of one, they give cumulative probabilities to seven decimals for the same values of p as the Romig tables (c.f. preceding review). Computation of these tables was begun at the Ballistics Research Laboratory, Aberdeen Proving Ground, Md. during World War II, and a limited number of copies were printed for official distribution in September 1952 as Ordnance Pamphlet ORD 20-1. They have just recently been made available to the public. Any checks sent in payment of this volume should be made payable to Treasurer of the United States.

A.C.C.

Local Section News

"...BUT NOT FORGOTTEN"

ALBUQUERQUE The results of the election of officers for 1954-55 were announced at the June 7 dinner meeting of this section. Following the meeting the group adjourned to Mitchell Hall on the University of New Mexico campus where David A. Hill, Hughes Aircraft, presented a preview of his convention paper "Improving Vendor Quality Relations."

BUZZARDS BAY The concluding session of the 1953-54 season of the Buzzards Bay section was a banquet at the New Bedford Hotel on Tuesday, June 15. Dr. A. V. Feigenbaum, General Electric Co., spoke on the subject "Organizing for Effective Quality Control Management."

CHICAGO 1953-54 was rung out with two excellent meetings in tne Educational Series. The first was on May 5 on the subject of analysis of variance, with the speaker Richard E. Ede, U. S. Steel Co. Applications to routine processing data were illustrated with emphasis on the significant relationships between the variables. The other meeting was on May 19 on the subject of sampling. Ray Swenson, I.I.T., and Harry Glading, Ford Motor Co., were the speakers. It would have profited everyone had they been able to attend this very instructive meeting.

CLEVELAND On May 7, the last regularly scheduled meeting of this section was held at the Cleveland Engineering Society. This meeting was celebrated as a Quality Control Day in Cleveland with an afternoon and evening session.

Robert Wagenhals of the Timken Roller Bearing Co., Canton, Ohio, was the speaker in the afternoon. His topic was "Inspector Evaluation and Capability."

This talk was followed by dinner in the Cleveland Engineering Society Dining Room. After dinner, the second speaker of the day, George Grossman, QC Consultant in Cleveland, spoke on "Evaluating Machine Tool Capability—Quality Control in Short Run Production."

On May 21, a special meeting of the section was held at the Cleveland Engineering Society. This meeting replaced the regularly scheduled meeting of Mar. 1, postponed by the Cleveland winter weather.

Guy G. Parkin, Minnesota Mining and Manufacturing Co., was kind enough to make a special trip to Cleveland so that the many members who were disappointed by the cancellation would have an opportunity to hear his discussion of "Significance Tests Applied to Industrial Process."

DELAWARE A record attendance of 59 persons attended the final meeting of the 1953-54 season on May 6 to hear Stuart J. Bugbee, E. I. duPont de Nemours, discuss "Applications of Statistics to Cost Control." An engineer in the planning division of the polychemicals department, Mr. Bugbee described a simple but effective system of cost control through the use of control charts.

DENVER "The Future of Your Quality Control Program" was the theme of a panel discussion by three Denver section members on May 28, held at United Air Lines New Operating Base Building in Denver. Leading off the discussion, Edward J. Wagner, Hackethorne Mfg. and Supply Co., pointed out that the future of any quality control program lies in one word, "Service." Charles W. Weller, Gates Rubber Co., extended the theme by presenting topics about the statistical aspects of "liveable" tolerances as an aid to research and production. Elroy J. Flaten, Rocky Mountain Arsenal, concluded the program by pointing out certain uses and economic advantages of acceptance sampling by variables.

ERIE On May 5 Burr Stanton of General Electric's Household Refrigerator Division, presented a program entitled "Selling Quality Control to the Factory." A motion picture on "Life Testing" and a series of film strips on "Machine Controls," "Process Controls," "Acceptance Sampling," and "Theory of Probability," which G. E. is using to sell quality control to foremen, operators, and inspectors were shown during the demonstration. The films which were produced by Snyder Art Studios were top drawer visual aids. Information can be had from Snyder Art Studios, 202 W. 24th St., Erie, Pa.

On May 25 a group of 13 hardy members drove 100 miles and back to visit the Lighting Institute at G. E.'s Nela Park, East Cleveland, Ohio. This was an "extra" event and was designated as Ladies Night. While the trip through the institute was well worth the effort, it turned out to be too far distant for most members to drive conveniently. Our next plant tour, as yet undetermined, definitely will be scheduled closer to home. So ye would-be planners beware—stick close to home when ye go a roving.

HUNTSVILLE N. R. Garner, Thiokol Chemical Corp., Redstone Arsenal, was the speaker at the May 19 meeting of this section. Mr. Garner spoke on "The Use of the Median as an Easy-To-Use Tool for Control Charts."

KANSAS CITY The May dinner meeting was attended by more than 50 members and visitors. Following the regular business meeting and installation of officers for the coming year, the chairmen of the section's committees were announced. A general discussion period followed with the membership making many valuable recommendation in the interest of further progress of the section.

MICHIGAN On May 14 the last session of the Michigan section was held at Wayne University in Detroit. At this meeting an announcement was made of the results of the election of officers for the 1954-55 season. The speaker for this final session was S. B. Sherwood who told us of the many and varied c chart applications at the Cadillac Motor Car Division of GM.

NEW HAVEN On May 13, the final meeting of the season, our guest speaker was Wendell H. Abbott of General Electric Company's Nela Park, whose topic was "Statistical Applications in Industry." A feature of the evening was the dinner at the Hotel Garde prior to the meeting. A good attendance by members and guests indicated that we can plan similar dinners for next season.

PITTSBURGH The Apr. 27 meeting was a great success judging by the attendance of seventy five members and guests. The subject, "An Application of Linear Programming" by Frank Carr and Fred Kindig, proved most interesting and the discussion which followed was equally instructive. When one selects an example from the steel industry, there will naturally be considerable interest on the part of a large segment of both members and guests of the Pittsburgh section.

At the last dinner meeting of the Pittsburgh section held at the Sheraton Hotel on May 25 a very interesting talk was presented by Albert J. Kukla, Aluminum Company of America, Buffalo, N. Y. Mr. Kukla outlined in considerable detail some of his quality control experiences in sand foundry operations.

Several members of the Cumberland subsection attended the meeting and a group from the Pittsburgh section plan to visit next fall at Cumberland, Md. The guests attending the meeting were: J. Robbins, Chairman; J. F. Lynch, Secretary; J. F. Bond and T. Knight.

ST. LOUIS The final meeting of the St. Louis section for 1953-54 was Ladies Night at the Claridge Hotel. This evening consisted of a buffet supper, dancing and the installation of officers for the coming year. Everybody got into the spirit of things and had a wonderful evening. As a matter of fact, it was the kick-off social evening for the 8th ASQC Convention.

SALT LAKE CITY The annual meeting of the Salt Lake section was held May 25 and was attended by 54 persons, the highest

this year. In addition to the annual report submitted by the treasurer and the secretary, we heard a talk from R. R. Nichols, United Air Lines Maintenance Base in San Francisco. Mr. Nichols spoke on QC uses in aircraft maintenance and flight line testing.

SAN FRANCISCO BAY AREA The San Francisco Bay Area section experimented with a new idea in dinner meetings at their June 7 session. A panel program was provided with the five panel members representing the following fields of interest: food, steel, brewing, metal working and statistics. Each panel member presented a short discussion of the most pertinent quality problem facing his company or industry. After this discussion, all members were organized into "buzz" sections and chairmen of the various sections put questions to the panel. Such sticklers as the preparation of specifications for heterogeneous raw materials (food industry), the setting of quality standards for a product subject to aging (brewing industry), use of vendor certification, and the materials review board were all attempted by the panel in a lively discussion.

SEATTLE Grant I. Butterbaugh, University of Washington, presented an interesting discussion of "Application of Correlation Methods of Quality Control" at the May 11 meeting of this section. Dr. Butterbaugh presented a general summary of common correlation methods and listed some of the typical applications of correlation analysis in industrial and commercial problems.

George Nelson, Bemis Brothers Bag Co., spoke on "What is Statistical Quality Control?" at the May 12 dinner meeting of the Seattle Management Club.

TRENTON The May meeting of this section had the honor of having Paul A. Robert, International Business Machines Corp., as guest speaker. He discussed "The Application of Punched Card Method to Quality Control."

"... CAST THEIR SHADOWS BEFORE"

KANSAS CITY "Gone Fishin'"

Ed.: This was the sentiment of several sections, not to mention your editor.

SAN FRANCISCO BAY AREA The next meeting of this section is being planned for early in August; the specific date will be announced later.

"FOR MANY ARE CALLED BUT FEW ARE..."

ALBUQUERQUE Election of the following officers for the coming year was announced at the dinner meeting on June 7: A. S. Hayes, chairman; A. F. Cone, vice-chairman; H. E. Viney, secretary; J. A. Orr, treasurer.

BUZZARDS BAY New officers for the 1954-55 season include: Robert Cooper, Bradford-Durfee Technical Inst., president; Russell St. Pierre, Acushnet Process Co., vice-president; Arthur Davidian, Wamsutta Mills, secretary; Norman Cobb, U. S. Rubber Co. treasurer.

CLEVELAND The officers for the coming year are: chairman, Charles R. Kendel, Lamson and Sessions Co.; vice-chairman, Dr. Fred C. Leone, Case Institute of Technology; secretary, Howard A. Schmidt, Aluminum Co. of America; treasurer, Paul Kuckuck, Weatherhead Co.

DENVER The Denver section is pleased to announce the results of the annual election held May 28 at the United Air Lines Operation Base, Denver. Officers elected for the 1954-55 season are: chairman, Richard H. Blythe, Air Defense Command; vice-chairman, Elroy J. Flaten, Rocky Mountain Arsenal; secretary-treasurer, E. Leroy Colbert, United Air Lines.

EVANSVILLE-OWENSBORO The following officers were elected for the Evansville-Owensboro section for the coming year: chairman, Harry C. Gregory; vice-chairman, James A. Cherolis; secretary, Edward L. Roehm; treasurer, Ellick B. Owen.

HARRISBURG The officers for this section for the 1954-55 season are: chairman, Edward F. Shurtleff, Thompson Products, Inc.; vice-chairman, Thomas Kerr, Aircraft-Marine Products; secretary, Harleth Unger, Middletown Air Depot; treasurer, John Deichert, Middletown Air Depot.

KANSAS CITY The section officers for the '54-55 administration installed at the May dinner meeting are: chairman, John B. Cobb, Standard Oil Co.; vice-chairman, Wm. Lamb, Jr., Bendix Aviation; secretary E. E. Cornelius, Fairbanks-Morse; treasurer, Robert C. Glynn, General Motors.

SALT LAKE CITY The officers for the Salt Lake City section, fiscal year 1954-55, were announced at the Annual Meeting May 25. They are chairman, Prof. H. Edward Flanders, University of Utah; vice-chairman, William Hoagland, Hill Air Force Base; secretary, Robert A. Cromar, United Air Lines, treasurer, La Mar D. Scott, Columbia-Geneva Steel.

TORONTO The new officers for the 1954-55 term are: chairman R. Alex Lucas, I.B.M.; vice-chairman, Marjorie Baskerville, Dominion Foundries and Steel; secretary, Kenneth Dale, Studebaker; treasurer, Robert Cardno, General Elctric.

TRENTON During the regular business meeting on May 4, the following officers were elected for the coming season: chairman, J. Kellock, Jr., Raymond Rosen & Co.; vice-chairman, J. Marks, American Steel and Wire Co.; secretary, S. Saunders, Stokes Molded Products; treasurer, H. Kleinhauf, Thermoid Rubber Co.

"AS YE SOW . . ."

MICHIGAN The Michigan section announces its Ninth Annual Michigan Forum to be held in cooperation with the University of Michigan at Angell Hall on the Campus at Ann Arbor. This will be an all day session held on Saturday, Sept. 11. The key speaker will be Dr. Harvey M. Merker, director of scientific relations, Parke, Davis & Company, Detroit. Technical speakers will cover subjects relating to automotive, paper, electrical, stamping, brewery, screw machine, management, receiving inspection, advanced statistical and other problems.

A basic education program will also be conducted. Speakers include Dr. A. V. Feigenbaum, General Electric Co.; Richard T. Trelfa, Watervliet Paper Co.; Glen S. Goodman, McQuay-Norris Manufacturing Co.; John Valentine and Everett H. Brink, Houdaille-Hershey Corp.; Steve J. Rogers, Ford Motor Co.; Dr. Lloyd A. Knowler, State University of Iowa; Dr. Brant Bonner, The University of Western Ontario; Winston Dalleck, United Air Lines; George W. McDermott and Edward Oakley, Delco-Remy Div., GMC; Dr. C. C. Craig and Dr. E. C. Yehle, University of Michigan; Dr. W. D. Baten, Michigan State College.

Further information concerning the forum may be obtained from Harmon S. Bayer, general chairman, 1154 Book Bldg., Detroit 26, Michigan.

IMPORTANT: Please note that the date of the Michigan Forum is given on the back of the 1954-55 membership cards as Sept. 18. This is a typographical error; the correct date is Sept. 11.

PHARMACEUTICAL QC GROUP Several representatives of pharmaceutical manufacturers, suppliers and consultants have recently organized informally into the Pharmaceutical Quality Control Group. The purpose of the group is to foster a free exchange of ideas and to provide a means for discussing quality control problems peculiar to the pharmaceutical industry. The group is planning to meet regularly for lunch on the last Tuesday of each month, excluding December and the summer months.

At a recent meeting held at the Hotel Suburban, Summit, N. J. the following officers were elected: chairman, Jack Cooper, Ciba Pharmaceutical Products, Inc.; secretary and treasurer, Joseph W. Kouten, Carroll Dunham Smith Pharmacal Co.

UNIVERSITY OF MICHIGAN The University of Michigan has scheduled the seventh annual presentation of its ten-day intensive course in statistical quality control for Aug. 16-26, 1954, on the campus in Ann Arbor. This is the first course for executives and supervisory personnel; it is practical and mathematically non-technical. It includes the standard control charts and sampling acceptance plans together with other basic techniques.

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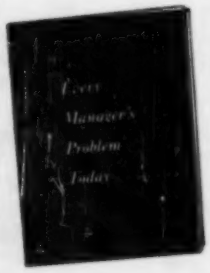

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San Diego will be host city for the First Western Regional Conference on Aug. 9-10. Shown above are (left) San Diego's convention queens, Jan Jones and Jan Golus; (center) the U. S. Marine Base, Convair Plant 1, Lindberg Field and downtown San Diego; and (right) stately California Tower, famed landmark in Balboa Park.

Instruction includes lectures, demonstrations, practice sessions, and conferences. In addition it is planned this year to tour the quality control installation at King Seeley Corporation.

Conducting the course will be the same experienced staff—Irving W. Burr, Purdue; Edwin G. Olds, Carnegie Institute; and Eugene C. Yehle, University of Michigan. Special lecturers for this year's course will be Leo Harrington, King Seeley Corp.; Archie R. Jackson, Harmon S. Bayer Associates; Walter S. Oliver, Detroit Gear Division.

The fee for the course will be $100. Please address inquiries to the course director, Prof. C. C. Craig, 106 Rackham Bldg., Ann Arbor, Mich.

WESTERN REGIONAL CONFERENCE

With the dates of Aug. 9 and 10 drawing near, plans are approaching completion for the First Western Region Conference and Second Aircraft Quality Control Conference being cosponsored by the sections of the Western Region and the Aircraft Technical Committee. Headquarters for the conference will be the Ulysses S. Grant Hotel in San Diego.

Theme of the conference will be "Investment Dividends from Modern Quality Control Methods." Those attending will learn from leaders in the fields of civic government, industry and the armed forces the latest trends and the newest ideas for obtaining these "dividends."

General chairman for the conference is G. A. Covington, Convair, who will open the sessions at 9:35 Monday morning by presenting Mayor John Butler of the City of San Diego as the introductory speaker. Mr. Covington will also preside at the banquet Monday night and will introduce the guest speaker, Gen. J. T. McNarney, president of Convair.

Of particular interest to management will be the opening and closing sessions. The first session of the conference will be the keynote panel discussion "The Position of Quality Control in Our Modern Economy." Moderator for the panel will be J. Naish, executive vice-president of Convair. Panel members will be L. G. Hector, vice-president of Sonotone Corp.; Brig. Gen. C. H. Mitchell, chief of procurement AMC; Capt. J. O. Biglow, BuAer representative at Lockheed Aircraft Corp. and J. E. Rheim, executive vice-president of Rohr Aircraft Corp. The final session of the conference will be a second panel discussion "How to Give Management QC." Panel members will be D. A. Hill, Hughes Aircraft Corp.; H. G. Romig, International Telemeter Corp.; C. M. Boswell, quality control consultant. Moderator for this panel will be Earl Chandler, North American Aviation Corp.

The technical sessions of the conference are being presented in three groups. The first group dealing with aircraft problems is as follows: Commercial Airlines by W. C. Dalleck, United Air Lines; Aircraft Recycling by Allen Hull, United Air Lines; AF Aircraft by Col. C. F. Damberg, USAF, AMC; USN Aircraft and Weapons by Capt. J. D. Arnold, USN, BuAer; Operations Research by A. Boldyreff, Rand Corp.

The second group of sessions is devoted to miscellaneous industries as follows: Food Processing by E. T. Dalton, Pictsweet Foods, Inc.; Lumber and Wood Products by Charles Latimer, Nickey Bros. Inc.; Pharmaceutical by Dorothy L. Biggs, Cutter Laboratories; Electronics by Leon Bass, General Electric Co.; Industrial Chemicals by D. Foster, Beckman Instruments, Inc.

The third group concerns quality control techniques and are as follows: SQC Familiarization by R. M. Hubsch, Rohr Aircraft Corp.; Use of Sampling Plans also by R. M. Hubsch; Sampling by Variables by Prof. G. J. Lieberman, Stanford University; Vender Quality

Control by J. G. Cerina, B. Taft and F. J. Muccio, Pratt & Whitney Div. United Aircraft; IBM Punchcard Methods by J. L. Dunn, International Business Machines Corp. and P. E. Allen, Beech Aircraft Corp.

An Aircraft Technical Committee meeting will be held at the close of the final panel discussion. J. Y. McClure, Convair, will preside as chairman of the committee.

Plant tours are being planned for those who wish to extend their stay in San Diego through Wednesday, Aug. 11. Other tours or outings can be arranged to suit the convenience of those attending.

Further information about the conference or registration blanks may be obtained by writing to George A. Covington, gen'l. chairman, First Western Regional Conference, Consolidated-Vultee Aircraft Corp., San Diego 12, Calif.

SIGNIFICANT DIFFERENCES

L. W. Miller, a member of the Delaware section and formerly assistant manager of quality control of the Latex Div., International Latex Corp., has recently been appointed chief inspector. L. J. Steinhauer was appointed assistant manager of quality control.

John Kellock, Jr., newly elected chairman and past vice-chairman of the Trenton section, is now associated with Raymond and Rosen Co. of Philadelphia, Pa., as a QC Engineer. He was formerly with Chase Aircraft Co. of Trenton, N. J.

George Porter, 1952-53 vice-chairman, is now associated with General Electric Co. of Trenton. He was formerly with Kaiser Metal Products of Bristol, Pa.

Frank J. Hahn, of the Metropolitan section, has been appointed assistant director of quality control for the Engine Div. of Fairchild Engine and Airplane Corp., Farmingdale, Long Island. Mr. Hahn was previously chief inspector.

Clarence W. Burdick, a member of the Michigan section, and one of the newly elected executive directors of ASQC, recently left the Ford Motor Company to go with the Houdaille-Hershey Corp.

The University College of Rutgers University began its first college-credit course in SQC in September 1947. As an outgrowth of this experience, and to meet the expressed needs of the industrial community served by Rutgers, the State University of New Jersey, there was developed subsequently a program of courses in applied statistics and SQC leading to the degree of Master of Science. This program was approved and announced by the Graduate Faculty of Rutgers University in July 1951.

The accompanying photograph shows Dr. Lewis Webster Jones (extreme left), President of Rutgers University, with the first six candidates to receive the Masters degree under this program. From left to right these candidates are:

Frank W. Wehrfritz
Research Engineer, Esso Standard Oil Co.

Stanley Levine
Member QC Division, E. R. Squibb & Sons

Dr. William E. Gaunt (Ph.D)
Director Quality Control, E. R. Squibb & Sons

Gilbert L. Peaks
Statistical Methods Dept., Bakelite Corp.

William C. Frey
QC Chemist, Bristol-Myers Co.

Raymond L. Thatcher
Manager QC Division, E. R. Squibb & Sons

One feature which is believed to be unique about this Master's degree program in SQC at Rutgers is its availability to full-time industrial personnel. Courses in this program are offered through evening classes only. The student is restricted to a maximum of two courses per semester, thus requiring, normally, three years to complete requirements for the Master's degree.

The first six candidates to receive Master of Science degrees in SQC are shown with Rutgers University president, Dr. Lewis Webster Jones. The men are Dr. Jones, Frank W. Wehrfritz, Stanley Levine, Dr. William E. Gaunt, Gilbert L. Peakes, William C. Frey and Raymond L. Thatcher.

Since students in this program are employed in positions where the techniques taught can be applied directly in their daily work, emphasis in the Rutgers program begins with application and moves toward theory as the sequence of courses progresses. It is not difficult to teach SQC techniques to a good college graduate with a background in engineering or physical sciences—the difficulty arises in teaching him to recognize the important *places* to use the *right combination* of these basic techniques. One of the contributions of the Rutgers program is the bringing together of this training approach in modern statistics with competent personnel who are in positions to make effective applications.

Students who complete the program for a Master's degree study a sequence of four courses (minimum) where emphasis is on theory—theory that is appreciated more fully because of the knowledge of applications learned in the first courses. The point of view that underlies the design of the Master's curriculum is the philosophy that an understanding of the theory in statistics must be correlated with an awareness of the associated applications.

AMERICAN SOCIETY NEWS

(Continued from page 3)

80—Winnebago (Wis.)

Chairman: Alfred H. Fenner
Kiekhaefer Aeromarine Motors, Fond du Lac

Vice-Chairman: Ray N. Hollands
Marathon Corp., Menasha

Secretary: Edward Schuch
Fairmount Foods Co., Green Bay

Treasurer: Paul A. Ebert
Kohler Co., Kohler

The terms of three members of the Editorial Board expired on June 30 in accordance with the membership rotation plan. The three men who retired from the board with the Society's thanks for excellent service are Harold F. Dodge, Lloyd A. Knowler, and Edwin G. Olds. The three new members who are starting five year terms on July 1, 1954 are Charles A. Bicking, Allen T. Craig, and B. H. Lloyd.

The Metropolitan section recently contributed $50 each to the Shewhart Medal and Brumbaugh Award funds.

The competition for the Presidential Award for Section Management, which was held for the first time this year closed, on April 30. The award, consisting of a banner for display at section meetings and an engraved plaque, was presented to the competition winner, the Los Angeles section, at the annual banquet Thursday, June 10.

On Thursday afternoon, June 10, the 1954-55 Board of Directors met for the purpose of electing five of its members to serve as executive directors. The five new exective directors are:

Dale L. Lobsinger
Ervin E. Schiesel
Clarence R. Burdick
Paul K. Leatherman
Warren R. Purcell

As executive directors these five men, plus Raymond S. Saddoris, president, and Alfred L. Davis, junior past president, constitute the new executive committee.

ANNUAL MEETING 1954

The annual meeting of the American Society for Quality Control was held on Wednesday, June 9, at 4 p.m. For the first time this year president Davis arranged to have the annual reports of the officers available in

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Quality Control INSTRUMENTS

printed form. Complete bound copies of the reports were furnished to the operating and executive committees and to the board of directors; copies of the individual reports of each officer were available at the meeting for those desiring them. Because of this arrangement the president simply called on each officer to file his report with the executive secretary; oral resumes of these reports were therefore not given.

The report of the tellers committee was presented by Mary N. Torrey, chairman. The results of the election of officers for 1954-55 were as follows:

President: Raymond S. Saddoris

Vice Presidents:
Arthur Bender, Jr.
Paul A. Robert
Julian T. Toulouse

Executive Secretary:
Dorian Shainin

Treasurer: Leon Bass

The results of the voting on the two constitutional amendments and the one amendment to the articles of incorporation were as follows:

1. The constitutional amendment reducing fellow grade dues to the same as senior member dues, from $16 to $12, was passed.
2. The constitutional amendment to change the wording of the purposes of the society to omit the reference to "good fellowship" was passed.
3. The amendment to the articles of incorporation authorizing deletion of the reference to "good fellowship" there, failed by default. While the percentage of ballots cast was considerably higher than last year and while almost all of the people casting ballots were in favor of the amendment, it nevertheless failed because we did not get ballots from 50 percent of the membership which was necessary to make the balloting valid.

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BOARD OF DIRECTORS MEETING

The 1953-54 Board of Directors held its final meeting on Friday, June 11, at 3 p.m. in the Statler Hotel, St. Louis, Mo.

Up for consideration at this meeting were five proposed changes to the by-laws. The first change applying to Article II, Sections 8 and 9, authorizes the Society to charter Divisions within its corporate structure. This was approved.

The second change was in connection with Article III, Section 11. This change recognizes the desire of sections to honor certain of its local members by paying their dues on a lifetime membership basis, but specifically prohibits the use of the term "Honorary Member" for these individuals, in order to avoid conflict with the Society's Honorary Members who may be elected only by action of the Board of Directors. This change was approved by the Board with the realization that it could not be made retroactive. However all sections currently having honorary members are urgently requested to consider the use of a different title for these individuals to avoid the above conflict.

The third change which was approved by the Board applies to Article VII, Section 27, and provides for increasing the number of vice presidents from 3 to 4 beginning with the 1955-56 fiscal year.

Change number 4 referred to Article X, Section 52a (1), (2), (3) and (4.) This change was designed to bring up to date the Society's policies concerning the acceptance of advertising in *Industrial Quality Control*. The change was approved by the Board, with the exception of Section 52a (4).

The last change considered by the Board concerned Article XII, Sections 56, 57 and 59. This one was drawn up to formalize the operations of the Shewhart Medal and Brumbaugh Award committees. After considerable discussion the Board voted to table this proposal until its next meeting in order to permit further study.

The Board approved the establishment of the Brewing Industry Technical Committee and the appointment of Donald F. Sager, Anheuser-Busch, as its chairman.

At its meeting in Providence on Nov. 7, 1953, the Board approved the report of the section representation committee. This report was a permanent plan for determining the various Society districts and the number of directors to be elected from each. It set forth several basic guides by which the Society could be redistricted from time to time to account for changes and shifts in population.

Using the guides set forth in this plan the executive secretary, Dorian Shainin, presented to the Board a specific redistricting plan to become effective on July 1, 1954 and to serve as the basis for electing directors who will take office on July 1, 1955. This proposal, which divides the Society into 16 districts, was approved by the Board and is being put into effect.

The new districts and their constituent sections are shown in the following tabulation:

Dist.	Section	Membership Mar. 31, 1954
1	Boston	143
	Buzzards Bay	49
	Burlington	42
	Hartford	144
	New Hampshire	19
	New Haven	83
	Rhode Island	56
	So. Connecticut	123
	W. Massachusetts	83
	Worcester	56
		798

Dist.	Section	Membership Mar. 31, 1954
2	Albany	127
	Buffalo	79
	Mid-Hudson	115
	Rochester	130
	Southern Tier	107
	Syracuse	145
	Utica	33
		736
3	Metropolitan	596
4	Montreal	77
	Toronto	91
	Western Ontario	68
		236
5	Allentown-Bethlehem	55
	Danville-Sunbury	...
	Erie	46
	Harrisburg	90
	Lansdale	73
	Philadelphia	272
	Pittsburgh	100
	Scranton-Wilkes Barre	44
	Trenton	39
		719
6	Baltimore	103
	Carolinas	68
	Delaware	49
	Richmond	59
	Washington	93
		372
7	Cleveland	347
8	Cincinnati	128
	Columbus	98
	Dayton	107
	Parkersburg	33
	Toledo	90
	Youngstown	36
		492
9	Evansville-Owensboro	29
	Grand Rapids	70
	Greater Muskegon	28
	Indianapolis	273
	Muncie	131
	Northeastern Indiana	68
		599
10	Michigan	390
11	Chicago	556
12	Central Illinois	38
	Iowa	261
	Milwaukee	205
	Minnesota	100
	Racine	51
	Rock River Valley	48
	Winnebago	...
		703

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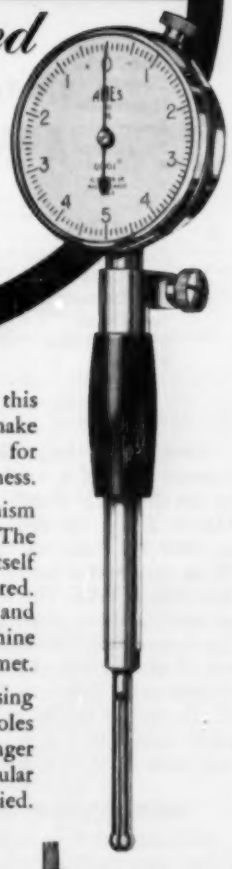

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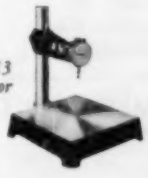

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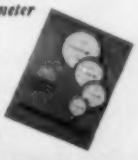

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Dist.	Section	Membership Mar. 31, 1954
13	Denver	49
	Kansas City	54
	Lincoln	47
	St. Louis	124
	Wichita	88
		362
14	Baton Rouge-New Orleans	31
	Dallas-Fort Worth	104
	Mexico City	31
	South Texas	58
	Albuquerque	...
		224
15	Birmingham	39
	Georgia	62
	Huntsville	11
	Louisville	67
	Tennessee	76
		255
16	Japan	71
	Los Angeles	231
	Salt Lake City	25
	San Bernardino	...
	San Diego	130
	San Francisco	81
	Portland	...
		604

According to the guides of the permanent plan, the total membership of the Society, which was 7989 on March 31, is divided by the total number of directors to be elected, 25, to arrive at a factor, K, which in this case is 319.6. The total members of each district is then divided by the factor K to determine the number of directors in the district. Using this formula Districts 1, 2, 3, 5, 8, 9, 11, 12, and 16 will elect two directors each; Districts 4, 6, 7, 10, 13, 14, 15 will each elect one director.

MEMBERSHIP CORNER

Although this is summer and it seems that local section activity has ceased for the most part, membership committees should realize that this is the time to take concrete action and make plans for the coming year. Each section has been sent a manual of procedures for increasing membership along with instructions to turn this manual over to the new officers and committee chairmen, however, there is a chance some sections may slip on this. It therefore behooves the membership committee chairman to make sure that this transfer has been accomplished. Ideas for next year's membership program will be found in this manual. It is urged that the newly appointed committee get into action at this time.

POSITIONS WANTED

Address all replies to box number references to: American Society for Quality Control Room 5736, 70 East 45th Street, New York 17, N. Y.

Presently employed, Quality Control Engineer, age 35; fluent in French and English; ten years in the electronics field, (radio, television, electrical appliances, etc.); two years in quality control. Have designed all types of sampling plans, including single, double, sequential, and moving line, and administered same. Varied experience with setting up of statistical experiments. Require a position anywhere in Canada, as QC supervisor, or assistant. For complete resume, please reply to Box 11A1 at the above address.

QC MANAGER seeking responsible position with company desirous of genuine quality control program. Age 35. Ten years experience in administering large inspection and laboratory force on mechanical products, chemicals, paper, textiles and foods. Expert on military specifications. Led Defense Department task group on preparation of MIL-STD-105A. Heavy academic training in sciences and mathematical probability. Senior member of ASQC. Strong on practical adaptation of QC theory. Please reply to Box 11A2 at the above address.

MEMBERSHIP CERTIFICATES

This is a reminder that certificates of membership suitable for framing are available for $3.00 from the Society Headquarters Office at New York.

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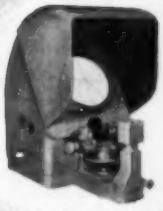

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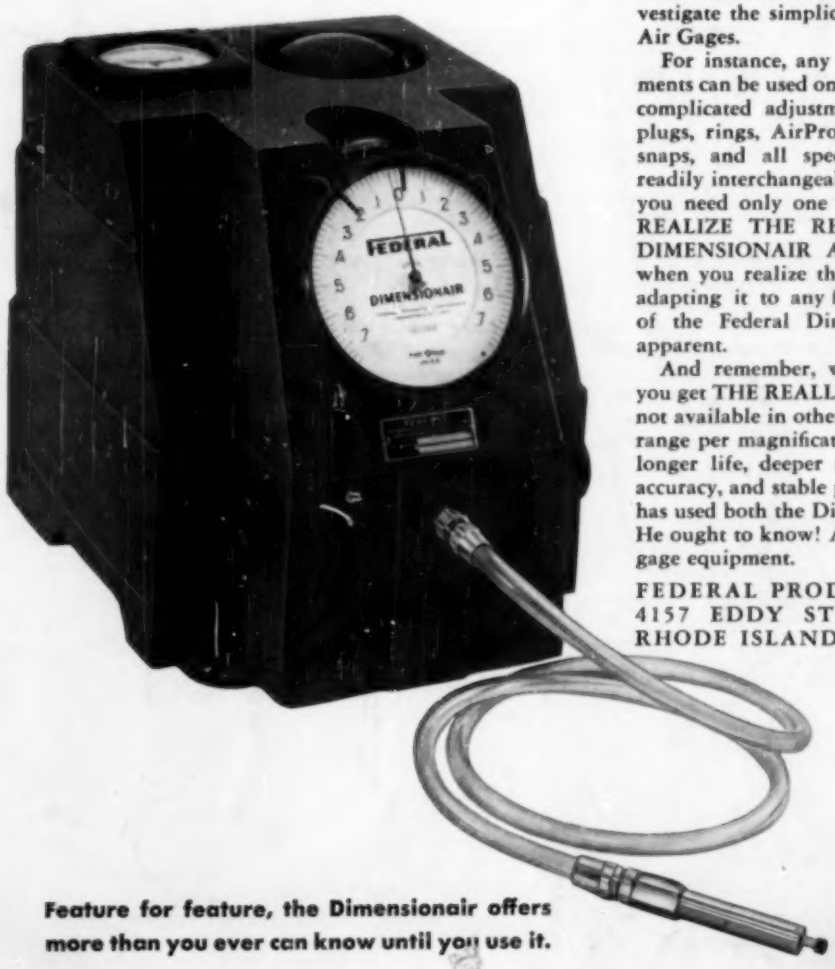

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